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Modeling F/A-18 flight hour program costs using regression analysis

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This thesis is an in depth analysis of cost variance in Naval Air Reserve units flying the McDonnell Douglas F/A-18. The purpose of the thesis is to identify, analyze and quantify the effect of variances in the cost per flight hour of the Naval Air Reserve's Flying Hour Program. The study begins with a review of the Planning, Programming, and Budgeting System which is used to justify and fund the Flying Hour Program. Then three different methods of determining Flying Hour Program requirements are described. The four components of cost per hour within the Flying Hour Program (Fuel, Organizational Maintenance Activity, Intermediate Maintenance Activity and Aviation Depot Level Repairables) are defined. Finally, using regression analysis techniques, these four components of F/A-18 cost data are analyzed on the basis of the intensity of aircraft utilization: flight hours. The analysis includes a regression model to provide budgeters at the headquarter or squadron level the means for predicting aircraft maintenance and fuel costs given a utilization rate. The thesis concludes with areas recommended for further research.

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MODELING F/A-18
FLIGHT HOUR PROGRAM COSTS
USING REGRESSION ANALYSIS

by

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Lieutenant Commander, United States Naval Reserve
B.S., United States Naval Academy, 1980

Submitted in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

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December 1994

ABSTRACT

This thesis is an in depth analysis of cost variances in Naval Air Reserve units flying the McDonnell Douglas F/A-18. The purpose of the thesis is to identify, analyze and quantify the effect of variances in the cost per flight hour of the Naval Air Reserve's Flying Hour Program. The study begins with a review of the Planning, Programming, and Budgeting System which is used to justify and fund the Flying Hour Program. Then three different methods of determining Flying Hour Program requirements are described. The four components of cost per hour within the Flying Hour Program (Fuel, Organizational Maintenance Activity, Intermediate Maintenance Activity and Aviation Depot Level Repairables) are defined. Finally, using regression analysis techniques, these four components of F/A-18 cost data are analyzed on the basis of the intensity of aircraft utilization: flight hours. The analysis includes a regression model to provide budgeters at the headquarters or squadron level the ability to predict aircraft maintenance and fuel costs given a utilization rate. The thesis concludes with areas recommended for further research.

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I. INTRODUCTION

A. BACKGROUND

> The Navy and Marine Corps operate forward to project a positive American image, build foundations for viable coalitions, enhance diplomatic contacts, reassure friends, and demonstrate U.S. power and resolve. Naval Forces will be prepared to fight promptly and effectively, but they will serve in an equally valuable way by engaging day-to-day as peacekeepers in the defense of American interests. [Ref. 1: p. 4]

Forward and day-to-day operations are the key phrases in the above quote from the 1992 mission statement for the Navy and Marine Corps. Signed by the then Secretary of the Navy, Mr. Sean O'Keefe, this paragraph sketches the Naval Service's direction for the future. In spite of the draw-down of naval personnel and shrinking military budgets, the Navy and Marine Corps will continue to be underway projecting the will of the American people overseas and protecting those interests deemed necessary by the command authority of the United States government.

To meet these operational commitments, the U.S. Congress amends and approves the President's annual defense budget request which includes funding for the Department of the Navy. Within the Navy's budget, funding is assigned to the Naval Flight Hour Program. This funding provides the means for Naval Aviation, one instrument of fleet power projection, to train and operate on a day-to-day basis. The Planning, Programming and Budgeting System (PPBS) is the process by which managers analyze their costs, predict requirements, and justify and forward their requests for funding. But every fiscal year the budget must be validated: the resultant funding must be efficiently and effectively executed at every level so that each training and operational sortie maximizes the investment being made by the American taxpayer. Because

the funding levels are shrinking and the operational and training requirements for the remaining units are not, it has become even more critical that program managers use every tool available to responsibly manage the taxpayer dollars in their care.

The specific appropriation within the Department of Defense's budget from which the training and operational forces of the Navy receive their funding is labeled the Operations and Maintenance, Navy or O&M,N. This account provides funding to all operating components: surface, subsurface, aviation, Navy and Marine Corps. In terms of the aviation component, all operational and training squadrons of the Active and Reserve Navy and Marine Corps and many of the maintenance activities are funded from this appropriation.

In preparing its request for funding, the Navy estimates the number of flight hours that will be required to ensure that pilots and squadrons are combat ready. The estimated costs incurred to support these hours are computed under the headings of: Fuel, Organizational Maintenance Activities, Intermediate Maintenance Activities and Aviation Depot Level Repair. These funds then provide for land-based and carrier-borne squadron training, administration, support, maintenance and operations.

Once approved by the U.S. Congress, the Flight Hour Program is a monetary cap constraining the maximum operational and training costs for all naval aviation assets. As this figure is passed down through the echelons of command, many managers will withhold a percentage, divide the remainder and pass it to their reporting commands. At the squadron level, managers track their funding to maximize mission readiness and spend exactly 100% of their allotted funding. Any command exceeding its funding must petition Congress for additional funding, unless the commands they report to can make up the difference from the withheld percentage or other units'

excesses. However, few commands spend less than their allotted amount, fearing a corresponding reduction in funding the following year.

There are few differences between active and reserve squadrons. Since the data forming the basis of this thesis is provided by Commander Naval Air Reserve Force, the focus will be on the processes and costs affecting the United States Naval Air Reserve. The Naval Air Reserves have the same training requirements and fly the same missions as their active duty counterparts. The Reserves' budgeting procedures also closely parallel the active duty. In both components, the failure to accurately manage funds and predict costs driven by the operational tempo and continuing cut backs in funding may cause aviation units to cease training and local operations so deployed units can continue to fly on the remaining funding.

Although the methods may change over time, the end result is the same. At every level, from the President and the Congress of the United States down to the Mission Commander flying off an aircraft carrier's pitching deck, managing funding for maximum combat readiness and operational capabilities is the goal. The security of the United States, the fighter pilot's life and, finally, mission readiness all depend on maximizing scarce resources to get the most out of every flight, whether the task is training a nugget pilot in sunny Pensacola or flying in combat on a dark and stormy night over hostile territory.

B. THESIS OBJECTIVES

The primary objective of this thesis is to add to the understanding of flight hour costs and the causes and effects of various decisions and factors influencing them. The end result of this analysis is to expand and improve the methods

available to Flight Hour Program managers tasked with efficiently budgeting scarce appropriated funds.

The questions to be answered by this thesis are:

1. Can statistical methods be used to model and accurately predict either the total annual flight hour costs or any of the four components making up the total flight hour costs for the Naval Air Reserve units flying the McDonnell Douglas F/A-18?

2. If a statistical analysis is a useful tool for evaluating flight hour costs for the Naval Air Reserves, what are the essential variables for predicting total annual costs and can they be applied to other active or reserve squadron type/model/series aircraft?

3. Given the present austere fiscal environment, can mathematical techniques, like regression analysis, lead to quantitative improvements in the budgeting process?

C. SCOPE

Mathematical techniques are used to identify, analyze and define a working model of aircraft costs per flight hour (CPH). Ideally, for a model to be a reliable fiscal management tool, it must be able to predict, within an acceptable margin for error, the end of fiscal year CPH for a given Type/Model/Series (T/M/S) aircraft. As the year progresses funding managers are trying to exactly spend to their funding targets, while maintaining maximum readiness. Therefore prediction accuracy will increase as the number of data points increase and the end of the fiscal year nears, the goal is to generate an acceptable outcome based on mathematically identified trends and with only two or three months of data.

Where possible, an analysis of the factors contributing to the costs of flying naval aircraft is conducted and relationships identified to aid in a better understanding of

the requirements for the differing T/M/S aircraft and their missions. This information may then be used as a basis for predicting the change in costs due to changes in the variables affecting Cost per Hour.

Data used in the thesis was provided by Commander Naval Air Reserve Force as reported to them by the various Navy and Marine Corps Reserve F/A-18 squadrons. Although the general assumptions used and conclusions of this thesis may apply to other T/M/S aircraft, the differences in T/M/S, missions, and maintenance practices may be significant. Additional research will be required prior to applying assumptions and conclusions from this thesis to other aircraft and to differing situations. It is also important to note that the costs used are exclusive of aircraft lifecycle, research and development, and procurement costs. Pay and benefits for the men and women that maintain and fly the aircraft and associated costs are also reported separately and therefore not considered in this thesis.

D. METHODOLOGY

Flight hour cost information and the corresponding number of flight hours flown by the Navy and Marine Corps Reserve F/A-18 squadrons were provided by Commander Naval Air Reserve Force. The cost information was tracked by its four component parts: Fuel, Organizational Maintenance Activity (OMA), Intermediate Maintenance Activity (IMA), and Aviation Depot Level Repairable Maintenance (AVDLR). These four components of cost information, for Fiscal Years (FY) 1991 through 1994, are analyzed and form the basis for the resultant mathematical model.

The totals and component parts of the data are analyzed by Fiscal Year for trends and, using available statistical programs, studied by the methods of regression analysis. The results of the model are then compared to the results of

explained.

Information supporting the mathematical model and explaining maintenance relationships and practices impacting flight hour costs were obtained by interviewing personnel active in the fields of aircraft maintenance and cost management and tracking. The interviews were conducted via telephone and in person with personnel from Patrol Squadron 65, representing the Organizational Maintenance Activity perspective, Aircraft Intermediate Maintenance Department, Point Mugu, for the Intermediate Maintenance Activity view, and Commander Naval Air Forces Pacific, San Diego for the Depot Level perspective. Other interviews conducted included personnel from the Office of the Comptroller, Naval Air Reserve, Point Mugu and Commander Naval Air Reserve, New Orleans. Policies and procedures that helped to explain trends, anomalies and results formed the basis of the interviews and the search of applicable literature and reports.

E. CHAPTER ORGANIZATION

This thesis is divided into six chapters.

Chapter I clarifies the purpose of the documented research by providing the background, relevance, benefits and need for efficient flight hour budgeting. It states the research questions, the scope of the research, the objectives of the analysis, and the methodology employed in conducting the research. It also contains an overview of the thesis and its structure.

Chapter II reviews the present budgeting process, reporting, methodologies, and the importance of accurate cost per flight hour estimation at the Type Commander and operational levels. It introduces the three different methods used to predict Flight Hour Program requirements, their strengths, weaknesses, any assumptions and their potential

effect on the results of the analysis in the following chapters.

Chapter III presents the alternative methods for analyzing data and predicting trends and influences. The principles of regression analysis, the statistical procedure used to mathematically evaluate the data in this thesis, are highlighted. The importance of the entering variables and their meanings are defined. The potential impact of any simplifying assumptions are explored.

Chapter IV documents the modifications and assumptions used to modify each of the four cost pools for use in the analysis. The influences and potential sources of variation and their importance are introduced.

Chapter V summarizes the results of the regression analysis of the squadron data. The probable meaning and forces influencing the outcomes are explored for each of the cost pools.

Chapter VI presents the conclusions drawn from the research: empirical data drawn from the model and qualitative information obtained from the comparison of the various methodologies. There are also some suggestions for further research in related areas.

II. BUDGETING FOR FLIGHT HOURS

A. INTRODUCTION

> Development of flying hour requirements for the services has become more important as aircraft and missions have become more complex and budgets have grown more constrained. At the present time, the services develop their flying hour programs via the exercise of professional judgement. They decide what training events must be repeated with what frequency in order to achieve and maintain various levels of proficiency. This is a reasonable approach, but it leaves one with a flying hour requirement that is not explicitly validated in terms of the proficiency or safety of aircrews. The scarcity of resources has increasingly led to the request that flying hour budgets be justified in terms of improved operational capability. In other words, those responsible for the budget-- in the services, in OSD (Office of the Secretary of Defense), and in the Congress want better evidence about what we are getting for the money we spend on the flying hour program. In the absence of such evidence, it is likely to become increasingly difficult to justify funding for the flying hour program. [Ref. 2: p. 11]

The challenge to military financial managers is clear. The end of the cold war, like the end of every other war in American history, is driving cutbacks in the military. The recent military successes (Desert Storm, etc.) and the lack of a formidable, identifiable enemy are raising questions about the future need for and the extent and capabilities of today's armed forces. Funding cuts by the Executive and Legislative branches of government are in support of "the People's" desire for shifting tax dollars for use by non-military government programs. This "Peace Dividend" is shrinking the military infrastructure and making the military budget manager's job more challenging.

The managers of the Navy's Flying Hour Program (FHP) are constrained by two conflicting requirements: maximizing fleet aviation's readiness in order to maintain the highest levels of safety and efficiency, and maximizing the use of the decreased funds available. Because the different type/model/series (T/M/S) aircraft have varying costs per hour (CPH) to operate, the limited dollars appear to buy more in those squadrons costing less. Minimum aircrew flight hour and tasking requirements for the various T/M/S aircraft drive a more equitable distribution of the funds, however. Drastic cutbacks in funding have overcome many years of planning and have necessitated radical measures, new techniques and creative management to stay within the budget.

Despite the drawdown of American forces and funding cutbacks, a relentless operational tempo and various contingencies have required the continuing presence of naval assets around the globe. These operations have resulted in an unplanned increase in costs. Normally increases in costs can be offset by increased funding from Congress through a supplemental appropriation. But the already tight budgets, watchful constituents, and federal spending caps have precluded an increase in funding, and no extra money has been forthcoming from Congress. By the beginning of the fourth quarter of Fiscal Year 1994,[1] it was clear that there was not enough money for the Active Duty forces to continue operating to the end of the Fiscal Year (FY). So that units could continue to fly and operate while forward-deployed at the various trouble spots throughout the world, the difficult decision was made to cut back the training operations of units in the at-home portion of their operational cycles.[Ref. 3] Standing down a squadron for two to three months has several

[1]The fiscal year begins 1 October of the year prior and ends on 30 September of the given year. So the beginning of the fourth quarter would have been 1 July 1994.

negative impacts: aircrew and material readiness drop, morale plummets, safety drops, and tension rises, especially as rusty pilots start flying again.

The Reserve forces were also affected by the lack of funding. Despite standing down one of only two Reserve Airwings and its associated squadrons sooner than mandated, the Reserves had a significant FHP funding shortfall. By September, all drilling Reservists were asked to forgo pay for the last drill weekend of the Fiscal Year.

This chapter looks at the funding process through a description of the Planning, Programming, and Budgeting System (PPBS) and an overview of the execution phase. It will outline the Flying Hour Program, some different approaches to funding, some of the problems associated with the Navy's Flying Hour Program (FHP), and the importance of an accurate estimation of costs per flight hour.

B. THE PLANNING, PROGRAMMING, AND BUDGETING SYSTEM

The PPBS is a process by which the federal government identifies, prioritizes and allocates funds to the wide range of public programs mandated by the Congress of the United States. As a public good provided for the security of the people and institutions of the United States, the Navy and the Navy's FHP are funded through the PPBS. The complexity of the PPBS system precludes an in-depth analysis of it; however, a basic knowledge of the process is required to fully understand the challenges and some of the problems inherent in managing the Navy's FHP.

Although not always concerned with the same FY, some function of PPBS is in process the year around. As the present year's budget is being executed, the next year's is in the approval process, and planning for the programs that make up the budget occurs as much as six years ahead of time. The entire process is designed to coordinate the national planning

efforts across the services and departments, translate those plans into actual military force requirements, which can then be codified into prioritized budgetary demands so that resources can be allocated to meet those demands and stay within the confines of the discretionary portion of the national budget.

In 1990, the Congress passed the Budget Enforcement Act (BEA), mandating deficit reduction measures on both the discretionary programs and the entitlement portions of the national budget. [Ref. 4: p. C-3] Entitlements are those programs approved by Congress that grow, or shrink, based on participation of those entitled to the prescribed benefits. These programs represent funding requirements and can only be changed or rescinded by a change in the law, an act of Congress. Entitlements receive funding even without specific action by Congress. The funding for discretionary programs have to be approved every year. Without this approval, money is not available and the programs actually end. The Department of Defense (DOD) is just such a program and as such, without a budget, aircraft do not fly, ships do not sail and the people do not get paid.

The BEA limits the entitlement programs to zero-growth after considering inflation. The real deficit reduction efforts are made within the budgets for discretionary programs. The discretionary programs are sorted into one of three categories: international, domestic and defense. Each of the categories have spending limits imposed on both budget authority and outlays[2]. These spending caps are below the

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[2]Outlays are the actual payments made from the current or a prior years obligation. Some appropriation accounts allow for multi-year payments: long term projects, aircraft carrier construction for instance, are approved in a given year, but construction payments continue until project completion. Budget Authority is the maximum allowable amount that can be spent.

baseline, considering inflation, set by zero growth. Discretionary funds can be redirected between the three categories, so that any growth in one is offset by further reduction in one of the other two. Since 1990, deeper cuts in the discretionary category labeled defense have been used to support the other two. It is within this context that DOD has to design its budgets and distribute the approved, or appropriated, funding among the services: Army, Navy and Air Force.

1. Planning

As the name implies, planning is the first phase of the PPBS process. The purpose of this phase is to generate long-range national security strategies and policies based on threats to areas of national interest. Input is taken from the various intelligence agencies, the Commanders-in-Chief of various unified commands, Type Commanders, the National Security Council and Joint Chiefs of Staff (JCS) to assess areas of national interest and the likely threats.

After the threats are identified and strategies generated to counter them, then a suitable force structure can be developed to reach the strategic goals and support the desired policies. The services are tasked with developing the programs needed to achieve the required force structure. The Defense Resources Planning Board (DRPB) oversees the entire process through the budgeting phase. At this point it ensures that the end product, the Defense Planning Guidance (DPG) meets the requirements set forth in the President's National Security Strategy and the National Military Strategy Document. It also ensures that the resources needed are realistic and can support the proposed programs and infrastructure. Prior to the Secretary of Defense signing the DPG, draft copies are routed to the Secretary of Defense, the various unified command's Commanders-in-Chief (CINCs), and Type Commanders who then have an opportunity to raise any concerns or forward

recommendations. In this way, the services are made aware of the strategic priorities and concerns of the Command Authority and can begin steps to set policy toward supporting or countering them. (Refer to Figure 1.1.)

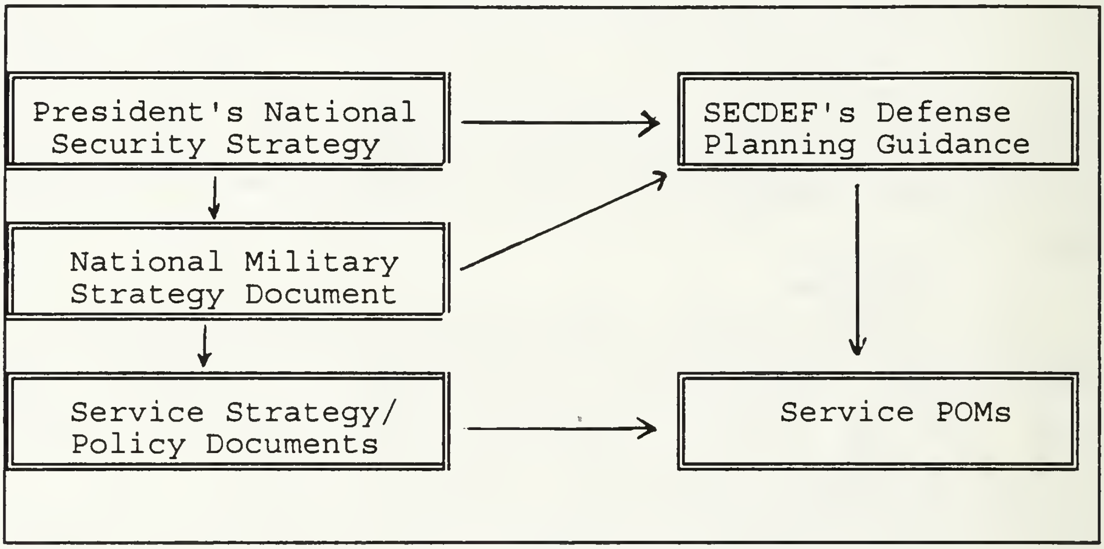

Figure 1.1: Planning Documents Flow. [Ref. 5: p. C-12]

At this point the DPG provides only very general fiscal guidance. It promulgates a Total Obligational Authority (TOA), the maximum total amount each agency or service can use to fund its programs for the next six years. As the end result of this phase, the DPG is signed by the Secretary of Defense and promulgates the necessary guidance for the services to begin development of their programs and forms the basis for the next phase-- programming.

2. Programming

"In the Department of Defense, programming is the process by which information in the Defense Planning Guidance (developed in the planning phase) is translated into a financial plan of effective and achievable packages (programs)." [Ref. 6: p. C-15] Producing a six year program every two years, the programming process starts with the last

four years of the previous program. The purpose of the process is to produce the six-year Program Objectives Memorandum (POM). The POM is the Secretary of the Navy's recommendation to the Secretary of Defense on the best use of the assets and resources allocated to the Department of the Navy. It contains information about the programs, including any planned activities, objectives and the costs associated.

Because each POM represents the middle phase, attempting to translate strategies and policies from the planning phase into a financial plan for programs requiring funding, it contains loose fiscal constraints. It is still possible to reallocate program funding within the TOA to better emphasize programs required to meet emerging threats. When a program is approved by the Secretary of Defense, its associated requirements--manpower, costs, construction plans, etc.-- are entered into the Future Years Defense Program (FYDP) and tracked for at least eight years. The FYDP is updated with changes over the course of the budgeting cycle, so it is possible to obtain program changes as the budgeting process continues. To obtain this information, a Resource Allocation Display (RAD) is printed.

The first two years of the six-year POM are used to prepare for the final budgeting phase. From January to May of the even POM year, the POM is refined through marks by the Defense Resource Planning Board (DRPB) representing cuts in funding because of insufficient justification. It is the task of the DRPB to ensure that the budgets are realistic in terms of the resources available. Requests without strong justifications are marked for reductions. Reclamas to the marks are prepared by CINCs and program sponsors to counter the proposed reductions and promote the recommendations and the needs of the fleet. Final decisions by the SECDEF are forwarded via Program Decision Memoranda (PDM) and in their final form present the requirements needed for the services'

budget requests. The budgeting process can then begin.

3. Budgeting

The budgeting phase of the PPBS process assigns the taxpayers' dollars to the programs approved in the previous stages: planning and programming. This phase consists of two primary steps: budget formulation and budget presentation and review. Budget formulation is guided by the Navy Comptroller via NAVCOMPT Notice 7111 series which provides the information needed by Navy program sponsors to transform the POM into a budget submission. The notice functions as a formal Budget Call. Some of the information contained in the note is:

- Instructions and guidance for the content of the budget estimates that are to be forwarded.
- The rates of inflation and foreign currency exchange rates.
- Any changes to the Department of the Navy (DON) Budget Guidance Manual requirements.
- The submission deadlines.

The budget call compels the offices responsible for budgeting to develop budget requests covering four years, beginning with the fiscal year currently in progress. The broad-based cost estimates in the POM are updated with the latest pricing information and schedules, funding shortfalls and problems are amended, and exhibits are attached justifying these and any other program changes. The budget requests are then submitted and reviewed at every level up the chain-of-command, through the Chief of Naval Operations to the Office of the Comptroller. A system of marks and reclamas is used to adjust the proposals and justify an unapproved request.

When NAVCOMPT disagrees with a budget decision made by a claimant, they will issue a "mark," adjusting the budget submission. More often than not, these are line item budget reductions. The budget submission office of the major

claimant responsible for the budget under review then has 48 hours to submit a reclama. The reclama should consist of new, amplifying information supporting the original funding amounts. The reclamas are reviewed by analysts and division heads within NAVCOMPT and, if passed, continue to the director of the Office of Budget and Reports. Unresolved differences are submitted through the Chief of Naval Operations or Commandant of the Marine Corps to the Secretary of the Navy for final determination. [Ref. 7: p. B-52 to B-53]

As of Fiscal Year 1993, the primary responsibility for budgeting for the Flying Hour Program rests with the Special Assistant for the Flying Hour Program, N-889E, under the Deputy Chief of Naval Operations for Resources, Warfare Requirements and Assessments, N-8. [Ref. 8: p. 15] As discussed in the next section, the program manager mathematically computes the program resource requirements using a series of formulas to find the cost per hour (CPH), the number of hours required by each type/model/series (T/M/S) aircraft and adjusts as required for inflation and program growth or cuts. The program manager, N-889E, makes the requested changes to the resource requirements of the Flying Hour Program and routes the budget request to N-08 and the Navy Comptroller, also known as N-82 or NAVCOMPT.

At this point, NAVCOMPT guides the submission of the Navy's budget. In addition to ensuring the POMs comply with the guidance promulgated by the DPG, it is also NAVCOMPT's responsibility to ensure that the resultant programs are justifiable and defensible before the Office of the Secretary of Defense and the Congress during the authorization and appropriation hearings.

The SECDEF holds hearings on the service's budget proposals with the Office of Management and Budget, which represents the president's interest. "These hearings are used by the SECDEF to formulate his Program Budget Decisions (PBDs)

and Defense Management Review Decisions (DMRDs). DMRDs seek to achieve economies and efficiencies by management reform." [Ref. 9: p. C-25] The PBDs are documented budget decisions by the SECDEF with concurrence of the OMB, and are returned to SECNAV for consideration. SECNAV then has the option of submitting PBD reclamas, drafted by the cognizant DON organization, in the effort to overturn a cut in funding. The decisions by the SECDEF become final after the Major Budget Issues meetings with the Commandant of the Marine Corps and the Chief of Naval Operations. The SECDEF's budget is then forwarded to the President for consideration and presentation to Congress as a part of the national budget. The presentation must occur by the first Tuesday in February, when the PPBS is ended and the congressional authorization and appropriation process begins. The congressional process ends with a presidential ratification of the national budget. This is ideally planned to occur by 1 October and, if completed on time, funding is made available to the various departments and thus to the FHP at the start of the fiscal year.

C. FUNDING THE ACTIVE AND RESERVE FLYING HOUR PROGRAM

The FHP budget request is consolidated with the other Navy program budgets to form the DON budget request, which is forwarded to the SECDEF and OMB for review. In its final form, it is submitted to Congress which may require the comptroller and program sponsor to:

- Provide further amplifying information.
- Brief congressional staff members.
- Testify before the budgeting and armed forces committees and/or on the floors of Congress to amplify and justify the FHP requirements.

On a yearly basis, Congress must appropriate money to the FHP as a part of the Navy's Operational and Maintenance

budget, frequently referred to as the O&M,N appropriation. Other appropriations affecting the FHP include the Operation and Maintenance, Navy Reserve (O&M,NR), Operation and Maintenance, Marine Corps (O&M,MC) and Operational and Maintenance, Marine Corps Reserve (O&M,MCR). From these appropriations the Navy pays for all its operational forces and maintenance capability: ship, aircraft, Marine Corps and Reserve. Consisting of approximately 30% of the total FY 1994 Navy budget of $77 billion, the O&M appropriations are second only to the Military Personnel appropriation which funds the pay, allowances, subsistence, and retirement accrual account and totals approximately 33% of the budget.

After authorization, appropriation and ratification of the budgets, funds are finally available to the OSD comptroller. If completed prior to the start of the new Fiscal Year, 1 October, funds are held until this date. If after the start of the new FY, then continuing resolutions may be passed by Congress to provide funds so that required operations may continue until the formal budget is passed. The apportionment process distributes the funds to the OSD comptroller and hence to the Department of the Navy. Within the DON, the funds are allocated to the various program sponsors and the Marine Corps.

D. EXECUTION

Overall managerial responsibility for the FHP is shared by the Deputy Chief of Naval Operations for Resources, Warfare Requirements, and Assessments, or N-889E and the Navy Comptroller, N-82. The FHP appropriations are divided into accounts for Fuel, Organizational Maintenance Activity (OMA), Intermediate Maintenance Activity (IMA) and Aviation Depot Level Repair (AVDLR). Then, granting obligational authority on a quarterly basis, the funds are allocated to the major claimants. The major claimants for the FHP are: Commander,

U.S. Naval Air Forces, Atlantic Fleet (CNAL); Commander, U.S. Naval Air Forces, Pacific Fleet (CNAP); Commander Naval Air Reserve Force (CNARF); Chief of Naval Eduction and Training (CNET); and Commander, U.S. Naval Forces, Europe. Since CNET and COMUSNAVEUR are a small part of the FHP with only a negligible impact on the FHP, they will be disregarded. Within limits, the O&M,N appropriation can be reallocated as the year progresses without informing Congress. So money can be shifted from ship steaming hours or overhaul, for example, to fund additional flight hours or make up FHP shortfalls due to higher costs per hour. The inherent danger exists though that the funding process in following years will funnel less funds to the accounts that the money is taken from, because of the implied lack of need and priority.

At the major claimant level, funds are again allocated to the airwings, and from there to the squadron level as an Operational Target, or OPTAR. The Commanding Officer has the final responsibility for maximizing aircrew and aircraft readiness without overspending the appropriation. Each allocation and reallocation is reported back to NAVCOMPT, where the obligation rates are tracked. Again, budget reallocations within the O&M,N appropriation can be accomplished without the concurrence of congress.

With the exception of the fourth quarter, Commanding Officers may exceed their quarterly FHP limits up to 105% with funding available from the wing or local comptrollers. The excess is taken from the subsequent quarters' allocation. The fourth quarter limit is held to 100% of the total FY allocation, and any excess, if not fundable by sources held in reserve at levels higher in the chain-of-command, must be investigated and explained up the chain-of-command to the Congress, NAVCOMPT and the Secretary of the Navy. To determine the levels of funding to release each quarter,

NAVCOMPT uses historical spending trends and the spending plans submitted with the budget requests.

The FHP funding (maintenance and fuel) for the Reserve Force Squadrons (RESFORONs) is controlled by squadron personnel under the guidance of the comptroller at the local Naval Air Reserve unit or Naval Air Facility. Only the funding for fuel is controlled directly by Regular Navy squadrons. The maintenance portion of the FHP funds--OMA, IMA and AVDLR--is sent to the supporting Naval Air Stations and ships, and when maintenance is completed the costs are ordered against the accounts.

E. FLYING HOUR PROGRAM DETERMINATION

The basic building blocks of the FHP are the number of flight hours required by pilots and aircrew in each of the various T/M/S aircraft in the Navy inventory and the cost per hour to operate these aircraft. The mission environments, types and durations vary widely between the T/M/S aircraft, from training units to active and reserve operational shore-based and carrier-deployed units flying search and rescue, patrol, ground attack, air-to-air intercept, test and evaluation flights. This mission variety complicates the computation of aircraft cost per hour rates and has led to a variety of methods and formulas for completing this crucial step in budgeting for the FHP.

1. Funding the Active Duty Forces Flying Hour Program

Funding for the Navy's Flying Hour Program comes from the Operation and Maintenance, Navy (O and M, N) appropriation. Revised early in 1993, effective FY 1994, the O and M, N appropriation is subdivided into four Active Duty Budget Activities (BAs), down from eight. Over 100 of the previous Activity Group and Subactivity Group (AG/SAG) codes were then simplified and assigned to one of approximately 20 AG/SAG codes under the new BAs. Prior to FY 1994, the FHP for active

duty forces divided the AG/SAG codes into the five BAs defined as:

- BA-1 TACAMO.
- BA-2 Tactical Air/Anti-Submarine Warfare (TACAIR/ASW), Fleet Air Training, Fleet Support.
- BA-3 Environmental Prediction (e.g., "Hurricane Hunters").
- BA-8 Pilot Training Rate (i.e., Training Commands for initial flight training).
- BA-9 White House Helicopters.

Now, the BAs are subdivided into four primary activities: (1) Operating Forces, (2) Mobilization, (3) Training and Recruiting, and (4) Administration and Servicewide Activities. The AG/SAGs further subdivide the BAs (see Appendix A); for instance, under the Operating Forces BA there are four AGs: Air Operations, Ship Operations, Combat Operations/Support and Weapons Support. The seven SAGs under the Air Operations AG which pays for the majority of the FHP are:

- Mission and Other Flight Operations 1A1A
- Fleet Air Training 1A2A
- Intermediate Maintenance 1A3A
- Air Operations and Safety Support 1A4A
- Aircraft Depot Maintenance 1A5A
- Aircraft Depot Operations Support 1A6A
- Base Support 1A7A

In addition, there are others that impact the FHP spread throughout the other BAs, AG/SAGs (TACAMO, for instance, is funded through the Combat Communications SAG under Combat Operations/Support).

Both the Naval Reserves and the Marine Corps use the same BAs, AG/SAGs and funding codes as the Active Duty forces. However, as in the case of the Operation and Maintenance, Navy Reserve appropriation which uses BA-1 Operating Forces and BA-4 Administration and Servicewide activities, only a limited number are applicable (again, see Appendix A for the complete breakdown).

The formal process for computing the required funding for the active duty TACAIR/ASW units used by N-889E is much more involved than the procedures used by the Naval Air Reserve for similar reserve aircraft. The process is defined by six formulas:

1. (Primary Authorized Aircraft (PAA) per unit) X (Crew Seat Ratio) = Number of Allowed Crews per Squadron

2. (Allowed Crews)X(Aircrew Manning Factors) = Budgeted Crews per Squadron

3. (Budgeted Crews) X (Required Hrs per Crew per Month) X (12 Months) = Required Annual Flying Hours per Squadron

4. (Req Annual Flying Hrs per Squadron) X (Number of Squadrons) = Total Annual Flying Hours Required

5. (Total Annual Flying Hrs Required) X (Primary Mission Readiness Percentage) = Annual Budgeted Flying Hours

6. (Annual Budgeted Hrs) X (Cost per Hour) = Annual Budgeted Cost

In essence the number of crews, aircraft and desired Primary Mission Readiness rate determine the budgeted costs. The number of aircraft assigned to a unit (PAA) and the number of crews assigned to operate them for full combat readiness is set by the program sponsor, N-88. The Primary Mission Readiness (PMR) rates are percentages of flight hours required to maintain full combat readiness by the aircrews on a monthly basis. The PMR rates and the percentage of simulator time are

frequently adjusted by NAVCOMPT to obtain savings in the FHP. The historical rates [Ref. 10] have been set at:

- FY 1990: 87% PMR (including 2% for funding flight simulators)
- FY 1991: 87% PMR (including 2% for funding flight simulators)
- FY 1992: 85% PMR (including 2% for funding flight simulators)
- FY 1993: 85% PMR (including 2% for funding flight simulators)
- FY 1994: 88.7% PMR (including 2% for funding flight simulators)
- FY 1995: 86.7% PMR (Projected PMR: using this figure results in a predicted $31 million shortfall in the FHP[3])

The PMR rate serves to enforce conservation measures and complicates management of resource dollars by the end user at the squadron level. Fewer funded flying hours do not change the minimum required pilot and aircrew hours for maximum combat readiness as set forth in training and readiness manuals and matrices. Imaginative techniques for cutting costs--fuel and maintenance--may be required to meet operational requirements and maximize training opportunities. No squadron Commanding Officer wants to overspend the FHP accounts. Concurrently, however, squadron funding,

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[3] The shortfall results from a lower amount of funding provided by the Op-20 (the document from NAVCOMPT defining program resource levels) than that required to maintain the stated PMR for TACAIR. Not all aircraft are funded on PMR, logistic aircraft budgets, for instance, are driven by utilization rates. If more funding is not forthcoming, then money can be redirected from logistic squadrons (lowering their availability for tasking, but not yet impacting flight safety or readiness) to the TACAIR units which are at the margin for pilot flight safety and readiness (approximately 135-140 hours per pilot per year).

maintenance, operations and training managers are not motivated under the current system to obtain any net cost savings.

It is frequently implied by higher operational authority that the failure to obligate allocated funds by 30 September will result in commensurate cutbacks in funds the next year. At every level of the chain-of-command, the assumption is made that unspent funding indicates an excess of resources required to do the assigned missions, so the excess is channeled to other units demonstrating the need and management ability to use 100% of the assigned funds. To maximize resource utilization, units aggressively manage remaining funding, resulting in a frequent "twelfth hour" surge in "training" flights, aircraft sitting on the ramp with the maximum allowable fuel loads, and maintenance purchases of high-dollar consumable parts, like windshields. The perception that funds have to be obligated or will be lost in the next budget cycle has led to a "use it or lose it" mentality in times of relative plenty and was a major impediment to the efficient and effective utilization of resources assigned to the Navy's Flying Hour Program and may have distorted the need for funds in the follow-on budgeting process.

2. Funding the Naval Air Reserve Flying Hour Program

The Reserve forces use the simplest computations based on the number of flight billets assigned to find the number of flight hours and, therefore, the amount of funding required for safety and readiness. Although based on the same factors as the active duty formulas, the reserve formula is easily stated:

(Flt Billets) X (150 Hrs required) X (Primary Mission Readiness rate - 2.5% for simulator usage) = Annual Unit Pilot Flight Hours required.

Flight currency requirements are considered less critical for the aircrew, so the required number of annual flight hours

for Naval Flight Officers and aircrew are lower. Historically, the aircrew have been able to obtain their hours for currency and maintain their readiness requirements within the pilot flight hour funding constraints. Therefore, the aircrew flight hour requirements are not considered when budgeting and assigning flight hours to the squadrons.[Ref. 11]

There are some inconsistencies inherent in using these formulas. The formulas consider some flight billets which may not be filled, while in other flight billets, the pilots and aircrew are at different stages of training and capability. There may be a senior pilot who requires five to ten hours a month in different operational mission areas to remain combat ready, and another more inexperienced pilot may require extensive training in the rudiments of the aircraft and combat systems amounting to 10 to 20 flight hours per month or more.

Of course, these formulas also do not consider the differences in aircraft and missions in assigning flight time. This task is the responsibility of the individual comptrollers at the stations and supporting units. Frequently responsible for multiple squadrons of dissimilar aircraft, the supporting comptrollers are able to shift FHP funding between the squadrons. The only restrictions are that they must report the changes, and the changes cannot be so severe as to cause the 'donating' squadron to be unable to fly the assigned flight hours or meet commitments.

3. Funding Naval Air System Command Units

The Naval Air Systems Command (NAVAIRSYSCOM) consists of major air test facilities and squadrons. These units are tasked with conducting applied aircraft and missile research, development, and testing for the Navy, Navy contractors, or non-Department of Defense customers. The Pacific Missile Test Center (PMTC) at Naval Air Station Point Mugu, California, as a NAVAIRSYSCOM activity supports Naval Air Reserve units and flies Navy aircraft without funding from Commander, Naval Air

Forces, Pacific. PMTC is funded through the Defense Business Operating Fund, and to a lesser extent NAVAIRSYSCOM. Although this funding arrangement is not true for all NAVAIRSYSCOM units, PMTC's funding is of particular interest because of the manner in which the cost of operating its aircraft is predicted.

The Defense Business Operating Fund (DBOF) is a working capital, revolving fund. Activities within the fund conduct business (accepting work orders or flying missions as in the case of PMTC) by drawing funds from the DBOF corpus. Standard cost rates for overhead and flight activity have been computed, and the customer is billed according to the use of the activity. The DBOF is then repaid, hence the title: revolving fund. The revolving fund was established on 1 October 1991 (FY 1992), and is intended to operate on a breakeven basis. This requires the DBOF activities to charge their customers an equal amount as their total costs--full cost recovery. Customers reimburse DBOF activities their direct and a portion of the indirect costs from their appropriated funding accounts. The data in Table 2.1 show PMTC rates for using their F/A-18s. It should be noted that NAVAIRSYSCOM maintained responsibility for the Aviation Depot Level Repairable (AVDLR) costs, and paid them with appropriated funding. Therefore, these were not used in the rates and are not shown.

Prior to the start of a new fiscal year, the Director of Operations teams with personnel from the Comptroller Department to attempt to predict the total costs and estimate the flight hour, or fly, rates for the coming year. The fly rates are based on known, ongoing project aircraft utilization requirements, with a factor for unknown emerging requirements. The fly rates are computed for each of the 14 T/M/S aircraft flown by Navy pilots and aircrew at PMTC. In addition, the flight crew must maintain flight currency requirements so,

based on flight billets assigned, additional time may be considered.

Cost Category	F/A-18A	F/A-18B	F/A-18C
Civilian Labor	$158,635	$143,325	$157,387
Civilian Travel	$636	$3,173	$5,395
Fuel	$32,239	$157,225	$256,244
Material and Parts	$379,699	$84,610	$88,368
Gnd Sup Equip	$9,649	$48,175	$81,900
Level 2 Costs	$5,098	$25,455	$43,274
Contracts	$150,940	$150,940	$150,940
Misc	$14,170	$70,747	$120,274
Total Costs	$751,066	$683,650	$903,782
Reg Flt Rate	$4,397	$4,397	$4,397
Reg Income	$146,860	$776,950	$1,432,103
PMCF Rate	$1,673	$1,673	$1,673
PMCF Income	$12,715	$46,844	$37,308
Test Income	$17,750	$0	$0
Total Income	$181,325	$839,794	$1,531,411
Variance	$(569,742)	$156,144	$627,629

Table 2.1: PMTC FY 1993 F/A-18 Cost/Income Totals. [Ref.12]

Total costs for each aircraft, based on historical data and inflation rates, are then applied to find the projected hourly rates charged for the use of each aircraft (Reg Flt Rate). These rates are also shown in Table 2.1. The costs that vary with the amount of flight hours consists of the charges for consumables and some maintenance actions. This usually totals to a little over half the total operational and support costs. Other costs do not vary with flight hours, these costs consist mostly of charges for overhead. PMTC will

then compute and use a slightly lower rate for charging the Navy for aircraft tasked for flight proficiency training and maintenance, since these tasks do not incur project overhead (minimal civilian labor costs, etc.). These rates are listed in Table 2.1 under the PMCF (Post Maintenance Check Flight) Rate.

Level 2 costs, listed in Table 2.1, are those costs charged for ordnance, flight safety, and flight clothing. In essence, this category covers costs directly related to flying the missions.

The principles of the working capital and revolving fund concept requires charging customers--DOD and non-DOD activities--for the use of PMTC's services. Defining its services in terms of the number of hours of aircraft flight time required generates a few problems. Although PMTC personnel have proved to be fairly accurate in predicting the fly rates and costs, government downsizing and project cutbacks are a concern for the PMTC staff. As customer's shrink and the demand for PMTC's services diminish, the invariant costs, or overhead, become a larger part of the rates charged to the remaining customers. Higher costs concern customers, causing them to shrink demand further, and a vicious cycle develops. Customers and potential customers find alternate ways for conducting research, development, and testing, and the ability to provide services diminishes with the loss in funding. The purpose of DBOF--to use commercial techniques for efficiency and effectiveness--results in the loss of capability due to high per flight hour costs and loss of the required customer base.

The most important aspect of funding flight hours at PMTC, Point Mugu is the ability of the program managers and budgeteers to predict the annual costs and, based on projected flight hours for the aircraft involved, to efficiently fund their program.

F. SUMMARY

In this chapter, an overview of the Planning, Programming and Budgeting System was provided. The products, reviewers and decision makers that participate in the complicated, years long process for budgeting the defense of the United States were identified. After the priorities have been set and the funds approved, allocated and apportioned, it is the responsibility of the Navy leadership to manage the funds in compliance with the goals identified to obtain them. The failure to manage these funds properly may lead to, at best, unfunded programs in the next budget cycle and, at worst, the failure of strategic policy to prevent war and/or poor tactical performance in time of war, leading to unnecessary deaths and destruction.

Three methods of predicting Flight Hour Program requirements used by three major claimants flying the F/A-18 were presented. Each used a different base and methodology to define the costs incurred, and each had different advantages, incentives, and drawbacks.

Chapter III will thoroughly define the process and methodologies used by budget managers at Commander Naval Air Reserve Force to predict the total costs and compute their budget input, the variances and baseline assumptions for the F/A-18. The methodology of regression analysis which is the technique proposed for modeling the costs per hour used in the FHP process is explained.

III. COST ANALYSIS AND ESTIMATING

A. INTRODUCTION

> The techniques used for estimating hardware cost range from intuition at one extreme to a detailed application of labor and material cost standards at the other. One military service manual on cost estimating lists five basic methods: industrial engineering standards; rates, factors, and catalog prices; estimating relationships; specific analogies; and expert opinion. Other sources put the number at two (synthesis and analysis), three (roundtable estimating, estimating by comparison, and detailed estimating), or four (analytical appraisal, comparative analysis, statistical analysis, and use of standards). [Ref. 13: p. 1-7]

There are a number of different methods for analyzing data and estimating costs in the budgeting environment. The three most common methodologies are: analogy, grass roots or engineering, and parametric. [Ref. 14: p 15] Each has its own advantages and disadvantages, and depending on the environment, any of the three may be the most appropriate for obtaining the goals of the analysis. Although the parametric technique using regression analysis is the primary analysis tool used in the next chapter, this chapter will define each of the methodologies in terms of the Flight Hour Program (FHP) environment and Reserve F/A-18 budgeting.

B. METHODOLOGIES

The use of any one of the three techniques (analogy, engineering and parametric) is dependent upon the limitations of the database, the underlying assumptions needed to simplify the analysis, and the goals of the analyst. Consistent with a given situation, the various techniques may accentuate one or more aspects of the relationship(s) within the data under analysis. The purpose of the analysis should be to ascertain as accurately as possible the cause and effect being analyzed

and model it as completely as possible without distorting that relationship. In this manner, consistently accurate predictions can be extrapolated. Therefore, using imprecise assumptions or a suboptimal technique may highlight only one particular facet of the relationship being analyzed and lead to errors in the subsequent prediction process.

All three methods are based on tools and techniques that are able to identify and define cost estimating relationships, or CERs. These CERs are a result of identifying the cause and effect of one or more facets that affect the cost and are the keys to accurate cost estimation. In his study of the Air Force's depot level maintenance cost allocation, Captain Bruce M. Kalish, USAF, noted:

> In the past, characteristics such as weight and thrust have been used to estimate aircraft airframe and engine costs, respectively. However cost estimators have continuously searched for other aircraft characteristics that (1) will provide consistently accurate estimates, (2) are logically related to cost, and (3) can easily be determined prior to actual design and development, thus allowing for trade-offs between cost and physical/performance characteristics. [Ref. 15: p 16]

The same principles apply after fielding a weapon system. Once the cost estimators are identified and if their relationships can be accurately determined, the same cost characteristics that were used prior to weapon system development may be used to predict the effect on costs after deployment of the system. Of course, after a data base of actual experience in the field has been built, then costs may be predicted using observed CERs. In any case, the data base may be analyzed by any of the following methods.

1. The Analogy Method

For the purpose of estimating costs, the analogy method uses the historical records of an analogous system with like characteristics to model and estimate the costs of the system or relationships under analysis. This method is dependent upon the assumptions that:

- Actual future costs will be affected to an equal degree by the degree by the analogous relationships used for the analysis.
- Any differences requiring adjustments can be identified and accurately quantified.
- The experience of the analyst is sufficient to identify differences in causal relationships and the magnitude of their effects. [Ref. 16: p 17]

This method is most appropriate when an analogous system with similar relationships exists and its data is readily available to the analyst. The method is often used to provide supportable, though usually "ballpark," information when time is a limiting factor or when the data for the desired relationship is unavailable.

The primary disadvantage of this method is that the costs are based on the characteristics and history of the analogous item. The causal relationships and effects on cost are not directly related to the performance of the item under analysis, rather they are hypothesized to be the same as in the past and the same as experienced by the parallel item. The entire method also depends upon the knowledge and judgement of the analyst and an ability to accurately identify the parallels, the differences and the magnitude of their effects on the analysis. Finally, the accuracy and effect of any adjustments must be carefully considered.

For budgeting, many cost analysts will use earlier, analogous systems to model the programs under analysis. In the case of the F/A-18 for instance, the cost functions of the

aircraft it replaced, the A-7, may be used as a starting place for analysis. The same techniques and cost factors can be assumed to affect the cost of the F/A-18 as its predecessor because it works in the same environment. Adjustments must then be made for the improvements in reliability and maintainability. This type of data is frequently available from component testing conducted prior to fielding the system. Because actual data concerning the field performance and cost is not available, the method is a viable alternative. Actual performance and cost may then reveal unforeseen relationships and (frequently) elevated costs, which may then be incorporated into follow-on analyses.

2. The Grass Roots or Engineering Method

This method is based on an extensive knowledge of all the component costs and relationships affecting the total or final system cost. This method relies exclusively on definitive knowledge of all factors affecting cost, their relationships and magnitudes. It is built on the assumption that future data relationships and their effect on cost are predictable and quantifiable from historical data on the components. With complete knowledge of each sub-component's reaction and effect, all the predicted causal factors can be extrapolated and summed for a net result.

The results of this method vary directly with the degree and accuracy of the analyst's knowledge of the system, its relationships, causes and effects. With extensive, well-behaved data, this method is usually preferred over the others. The theory underlying this method causes it to be inherently very precise, however the real-world drawbacks of the method account for its shortcomings. The extent of knowledge and amount of data required for this method of cost analysis is tremendously time consuming and usually not feasible or available. Any unquantifiable ambiguities and inconsistences account for significant errors.

The engineering method accounts, in part, for the extensive component testing required for new weapon systems. With extensive aircraft component performance data, maintenance costs and fuel usage can be predicted and properly anticipated. Relying on this form of information for predicting F/A-18 budget requirements led, in part, to the FHP budgeting problems experienced in FY 1994. Components of the new F/A-18 General Electric F-404 engines required maintenance more often than predicted (see Table 3.1). The Aviation Support Office (ASO) was prompted to cut in half the time required between conducting major overhauls of the F/A-18

COMNAVAIRESFOR
F-404 Engine Component Life Reductions

		Original	As of 1/94	% Life Lost
I.	FAN SECTION			
	Stage 1	5850 hrs	2200	62.3%
	Stage 2	8770	3100	64.6%
	Stage 3	4380	1700	61.1%
	Aft Shaft	9030	4600	49.0%
II.	HIGH PRESSURE COMPRESSOR			
	Stage 1-2	2240	1700	33.0%
	Stage 3	7480	3470	53.6%
	Stage 4-7	14560	12500	14.1%
	HPC FWD Shaft	4980	4000	19.6%
III.	HIGH PRESSURE TURBINE			
	Disc	10500	7200	31.4%
	Fwd Cooling Plate	2100	1600	23.8%
IV.	LOW PRESSURE TURBINE			
	Disc	10520	6240	40.6%
	Fwd Air Seal	22030	18000	18.2%
	Conical Shaft	12370	6700	45.8%

Table 3.1: F/A-18 Engine Component Life Reductions [Ref. 17]

F-404 engines. Since the engines are being pulled and replaced twice as often as anticipated from testing, the actual cost has approximately doubled. [Ref. 18] The budgetary shortfalls are a direct result of these unforeseen reliability changes. It may be argued that more extensive component testing of the engines may have identified the problems now being experienced. With prior knowledge, the budgets would have reflected the increased funding requirements and the present shortfalls would not exist, or at least would be much less severe.

3. Parametric Methods

This method uses mathematical techniques to manipulate historical data and define a formula to be used for prediction. Parametric methods, such as regression analysis, seek to define in mathematical terms all or part of the cause-and-effect relationships between two or more characteristics. Over the range defined by the data used to construct the mathematical formula, regression analysis can model the net of the relationship(s) between the variables, or any of the component parts. By limiting the relationships and a given range of data and using simplifying assumptions for the analysis, a system component cost can be identified. Conversely, the net result of the relationships affecting the entire system can be treated as one and, if consistent over the range being studied, accurate predictions obtained. The predictions will be dependent upon the given system and limiting assumptions; change either and the results will probably differ.

Parametric methods depend on consistency of the relationships and data over time. Any changes in the fundamental relationships within the data range or over time must be recognized by the analyst and the effect estimated using one of the other two techniques. With further documentation or data, the effect can be included in or

excluded from the original mathematical definition. If quantifying the effect is not possible, then the only other alternative is constraining the analysis in a manner to rule out the effect.

When analyzing the costs of operating F/A-18s, intuition suggests that the costs should be dependent upon the level of operations. That is, above a given threshold, the costs of operation should react to an increase or decrease in flight hours. For instance, fuel usage should increase with the number of flight hours flown, although below a certain level they will tend to level off due to a fairly constant ground consumption rate for maintenance purposes. For a squadron with its aircraft in preservation the usage should be nearly zero. Like fuel, the cost of maintaining the aircraft should increase as the number of flight hours increase. It would also seem logical that points should exist above and below which the maintenance costs would tend to level off. Above the upper bound, costs would tend to level off as an increase in flight hours would have little effect through additional maintenance required when compared to the level already required. Likewise a lower bound should exist, below which maintenance would still be required despite a further reduction in flight hours. Between these points, parametric assumptions and methods, such as regression analysis, should be able to accurately model the relationships of fuel and maintenance costs to the number of hours flown.

C. REGRESSION ANALYSIS APPLIED TO THE FHP

Because parametric methods seek to define the cause and effect relationship between two or more variables, one output variable must be linked, or in some way be dependent, upon the other, independent, variable. Regression analysis then uses multiple data points, assumes a stable, definable trend, and fits the data to a mathematical expression of the "typical"

cause and effect relationship. The independent variable is expected to vary over time and over an acceptable range for analysis. The dependent variable is expected to vary in a definable, consistent manner in concert with the independent variable.

When the dependent variable varies in a manner unexpected with the change in the independent variable, the result is a data point termed an outlier. The outlier may be one of two types: one inconsequential to the analysis, the other critical to accurate prediction. The first is a true anomaly caused by unpredictable influences and unlikely to occur again in the future. Once this type of outlier is identified, it should be removed from the data set. Deleting its influence from the relationship may further refine the assumptions upon which the results are based. Therefore, the analyst should exercise extreme care in modifying a data base.

The second type of outlier indicates a problem in the analysis. That is, there are recurring influences, or relationships, that have not been considered which have a demonstrable effect on the desired outcomes. If the influence of the affected data cannot be compensated for or quantified, then the assumptions or data range must be adjusted to exclude the reflected relationship.

One of the most important steps in analyzing a budgeting data base and estimating relationships is understanding and refining the data forming the basis of the relationship. Relatively minor flaws or inconsistencies in the data base can result in significant errors in the output. For this reason, the raw data must typically be purged of inconsequential outliers and adjusted for assumptions, format, time and range.

1. Assumptions. When using regression analysis for constructing a F/A-18 cost model, the basic assumption is that there is a direct relationship between maintenance and fuel costs and the flight hours flown. For the purposes of this

thesis, a critical corollary assumption is that this relationship will be linear over the range to be analyzed. This assumption greatly simplifies the model. Of course, unexpected variances in the results of the analysis can be traced back to these assumptions if they are erroneous and the relationships are, in fact, curvilinear. Any factors potentially affecting these assumptions must be considered and integrated into or removed from the data set.

Methods presently in use by Active and Reserve components for F/A-18 budgeting assume that fly rates and costs, adjusted for inflation, will be essentially the same as those during the past three years. To find the proposed budget submission, costs for the last three years are adjusted by the promulgated inflation indices and averaged together to obtain the new budgeting base. Generally, this method would suffice if costs and flight hours are driven by a consistent operational tempo. The last three years, however, have not been conducive to this procedure. Desert Storm operations and cost increases have skewed the averages. The Defense Business Operating Fund has been operating at a loss and so boosted the costs it charges to its customers. As already noted, F/A-18 F-404 engine life has been drastically cut, also increasing costs. The combination of these budgeting inconsistencies have prompted drastic measures.

To budget for FY 1995, the three year average normally used for budgeting was temporarily discarded in favor of using actual data for the five most expensive aircraft in the inventory. [Ref. 19] Although FY 1994 was a period characterized by the grounding of entire squadrons for lack of flight funds, with their aircraft placed in preservation to minimize maintenance costs, data was collected on the five most expensive aircraft types to adjust the budgeting base. The aircraft used were: F-14, F/A-18, AV-8, H-53 and the EA-6B. Many feel that opting for actual data during a period of

fiscal constraint, though better than the three year average, would still result in conservative estimates of cost. On the positive side, budgeting in this manner should be improved by the tie to the actual increased costs for these aircraft, should reflect the increased usage caused by a shrinking fleet, and capture the higher surcharges for depot maintenance. In this manner, the change will regain the current budget shortfalls.

2. **Format.** To insure a model using regression analysis successfully captures the relationship between costs and flight hours, the data base must be in a useable format, generally without extraneous computations or data. In this way, the fluctuations in flight operations between deployment and standdown and the effect on cost can be readily observed. This will also enable detection of leads or lags, if costs lag the operational tempo for instance. Of course layout is a part of format and is critical to the success of any analysis. As an example, data consisting of differing units can obscure any relationship.

3. **Time.** All relationships tend to change over time and this is true for cost relationships as well. Budgeteers already consider the effect of time by adjusting data for inflation. By treating each year as the year before when computing the three year average, however, major events affecting cost are ignored. As was experienced in budgeting for FY 1995, the base will soon be unacceptably out of bounds with reality, and drastic steps must be taken to catch up.

4. **Range.** As was previously illustrated, when data nears the extremes of its range, the relationship tends to distort. When analyzing a straight line relationship, it is usually best to be working with a steady-state system. Other models based on historical occurrences will frequently model fluid relationships better. For instance budget managers will frequently use historical costs to fund squadrons

transitioning between aircraft types. This situation frequently results in a long period of initial qualification, intense pilot training and high aircraft maintenance rates. A lower than normal number of flight hours and higher maintenance costs are reflected in the data. Depending on the assumptions, to base out-year budgets on a fluid transition period will distort requirements. If a squadron will always be in transition, then its effect can be programmed into the model. However, this will rarely be the case as fewer new Type/Model/Series aircraft are projected to be entering the fleet. In the instance that a squadron is transitioning, the information from previous units having already completed the transition process can be applied to adjust the model as required.

5. Sample Size. To build a regression analysis model with insufficient data may result in a mathematical equation that fails to adequately represent the extent of the relationships it is attempting to quantify. Other techniques, such as graphing, a "rule of thumb," or simply the analysts judgement, could be just as accurate and justified as well. The extent of the model, its assumptions and ultimate goals, should determine the sample size and whether or not there is enough data for the analysis.

Regression analysis is based on defining the relationship between a dependent variable and one or more independent variables. Since fuel consumption is assumed to increase with the number of hours flown for instance, then the independent variable described by flight hours has a dependent variable, fuel. These two variables are linked by a function that describes their relationship. Regression analysis methods attempt to evaluate that function. But the fuel consumption may also depend on other independent variables, engine efficiencies or ambient air temperature and pressure for

instance, and it is these other variables that contribute to variance in the model.

In contrast to the variables are constants. Constants remain the same regardless of variation in their environment. Systemized maintenance that is required on the basis of time, completely independent of utilization, weather, or any other condition, is an example of a constant. The cost of this type of maintenance may affect the magnitude of total costs, but will not affect the model. Because constants do not vary, regression analysis, or any other mathematical techniques, is not required to predict their future value.

To mathematically determine a straight line for the data pairs representing the dependent and independent variables, the method of least squares--best fit is used. This method uses all the data pairs not already ruled out as anomalous outliers. The data is weighted equally. That is, no pair is assumed to be more accurate than any other. Then a line is fitted that mathematically minimizes the differences between all the observed dependent values to their mathematical equivalent denoted by the line, the dependent value of the data pairs (the Y value) described by the equation. This method also assumes that the actual, observed data relationships will consistently vary within the analyzed range. That is, the actual data will always tend to minimize any differences from the typical value described by the fitted line. Therefore, the distribution will be normally distributed about the line, which is to say that the farther a point is from the line the less likely the observed point will occur. The equations and theory describing the regression method are based in calculus, however, the mathematical techniques used in actually performing regression analysis are found in simple algebra.

D. SUMMARY

This chapter has described three methodologies used for mathematically describing the relationship between two variables such as cost and performance. These are the analogous, the grass roots or engineering, and the parametric methods. The specific advantages and disadvantages of each in evaluating the function describing flight hours and its relationship to fuel and maintenance costs were explored. In times of restricted funding, it is imperative that military budget managers have realistic models describing program costs and performance. Realistic cost estimates and predictions can be the difference between obtaining the funding needed for flight safety and readiness and aircraft languishing on the ramps in preservation.

Some of the nuances of the parametric method used in this thesis, regression analysis, as well as the other two methods (the analogous and grass roots or engineering method) and their effect in analyzing budgeting problems, were thoroughly reviewed. The importance of a stable relationship within the analyzed range, adjusted for time, in a usable format and with adequate sample size to provide a meaningful result was emphasized.

Finally the basic theory of regression analysis and the least squares--best fit technique were reviewed. The idea of a function describing the relationship between two variables--one dependent upon and reacting to the other--was proposed for use to relate flight hours to the dependent variables of fuel and maintenance costs.

In the next chapter, the data base provided by Commander Naval Air Reserve Force is described. The assumptions and cost requirements unique to the F/A-18 data provided are discussed and the data translated into a usable format. The specific compensations made for various influences and those that could not be identified or quantified are delineated.

IV. F/A-18 FLIGHT HOUR AND COST DATA

A. INTRODUCTION

This chapter introduces the reader to the information provided by Commander Naval Air Reserve Force that forms the database for the analysis. There are various influences and many data characteristics potentially affecting the outcomes of the data analysis. Therefore, the database requires a number of mathematical adjustments to facilitate the use of regression analysis techniques and ensure usable, definitive results. Each section is devoted to the discussion of a single cost pool and the various influences, potential sources of error, and any methods used for compensation. The final section is a chapter summary.

B. THE DATA FROM COMNAVAIRESFOR

The data used in this thesis has been compiled by COMNAVAIRESFOR on reserve units flying the McDonnell Douglas F/A-18 for the Fiscal Years (FY) of 1991, 1992, 1993, and 1994. COMNAVAIRESFOR receives information on the Naval Reserve F/A-18 units from a required Memo Record Flight Hour Cost Report (Rpt Sym 7310-7), which is to be submitted by the tenth of a given month for the previous month. The report is prepared by the various station comptrollers for the squadrons they support and is sent via message format. The format for the report is provided as Appendix B. The Marine Corps Reserve F/A-18 units send their information via the Marine Corps Reserve headquarters in New Orleans, Louisiana.

COMNAVAIRESFOR tracks the monthly flight hours and cost data by squadron in a Lotus database. It is then used as a basis for the monthly Memo Flying Hour Costs Report which documents the Cost Per Hour (CPH) and flight hours flown by every Naval and Marine Corps Reserve squadron. To maintain compatibility and enhance the usefulness of this thesis and its findings, the data provided by COMNAVAIRESFOR was compiled

in a Lotus database, adjustments made as necessary, and analyzed using the regression analysis outputs provided by that software package.

Although monthly totals are reported by each unit, COMNAVAIRESFOR uses the information in a cumulative form based on Fiscal Year (FY). To obtain the cumulative flight hour numbers, the month's reported data is added to the previous months' to obtain the running total for the current fiscal year. Each month's Cost Per Hour (CPH) is then computed by dividing the total costs in each category by the total hours flown. The resulting numbers are cumulative, year-to-date figures. At the end of the fiscal year (FY), the results yield the CPH average and the total flight hours flown for the entire Fiscal Year. These totals are then easily compared to any estimates or maximum limits predicted at the start of the FY.[1] On 1 October with the new FY, the counters are reset to zero and the computations begin anew for the new FY funding. This analysis, to be consistent with the methods of and tools available to COMNAVAIRESFOR, uses the cumulative FY data.

The Memo Record Flight Hour Cost Report information tracked by COMNAVAIRESFOR that form the basis of the analysis effort are:

- The number of flight hours flown by each unit
- The total fuel costs for each unit
- The total Organizational Maintenance Activity (OMA) costs for each unit.
- The total Intermediate Maintenance Activity (IMA) costs for each unit.

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[1]For instance, at the beginning of the year, budgeters may project a maximum flight hour rate per squadron based on the number of pilots needing training in each unit. This will drive the disbursement of FHP funding. At the end of the year, the actual dollars spent and hours flown can be used to determine unit efficiencies.

- The total Aviation Depot Level Repairable (AVDLR) costs for each unit.

The number of flight hours represent the level of activity for each squadron and, it is assumed, is a significant driver in the magnitude of the other four types of data: the costs. The costs, then, are hypothesized to depend upon the flight hours. As the number of flight hours increase, there should be a definable reaction in the four costs--Fuel, OMA, IMA, AVDLR--that will cause them to behave in a predictable manner. As stated in Chapter I, the goal of this thesis is to identify, validate and quantify these relationships and build a model capable of predicting future cost behavior.

Intuitively, the level of activity is only one of the influences potentially affecting cost over time. When working with costs over a period of years, inflation must be considered. To accurately compare cost data from different years, it must be mathematically adjusted to represent monetary values measured at a single base year. The averaged inflation effect on cost can be reliably determined. The Navy Comptroller (NAVCOMPT) publishes an annual notice, NAVCOMPTNOTE 7111 [Ref. 20], containing its determination of the inflation rates as they affect the various Navy, Marine, Active and Reserve appropriations. The stated purpose of the notice is to disseminate this information and provide formats for use in budget preparation and submission. For the purposes of this thesis, all costs are in terms of Fiscal Year 1991 dollars. That is, all the cost figures have been deflated to their FY 1991 equivalent for comparison purposes.

The NAVCOMPT 7111 Notice also addresses the topic of fuel contracts. It provides the negotiated cost for all aviation fuels pumped into naval aviation aircraft at stateside bases. The fuel prices are given for JP-4, JP-5, JP-8 (JP represents jet propellant) and AVGAS (for aviation piston engines) in terms of cost per barrel. By using these contract prices, the

cost for fuel can be adjusted to a base year amount, Fiscal Year 1991 costs.

COMNAVAIRESFOR provided information on ten Navy and Marine Corps reserve squadrons flying the McDonnell Douglas F/A-18 Hornet. The squadrons are listed with their transition dates in Figure 4-1. The transition dates indicate the month and year that the squadrons began flying the F/A-18 and reporting the costs. Usually there is a transition period, of varying length, during which the unit is responsible for flying and maintaining the old and the new aircraft. This period will affect the analysis for those units. Not noted in Figure 4-1, two of the squadrons, the "Golden Hawks" of VFA-303 and the "Lobos" of VFA-305, were disestablished in July and August of 1994, respectively, as a part of the pending disestablishment of Reserve Carrier Air Wing 30 in September of 1994.

Flight hour and cost information from these ten units during the years of FY 1991 through FY 1994 form the data base for this research. But a number of assumptions are required if the information from these ten units is to be used for comparison purposes:

- Primary Mission Area--the differences in mission

Unit:	**Location:**	**Transition:**
MAG-41	Dallas, TX	October 1993
MAG-42A	Jacksonville, FL	June 1991
MAG-46	San Diego, CA	June 1989
MAG-49A	Washington, D.C.	January 1992
VFA-203	Jacksonville, FL	September 1991
VFA-204	New Orleans, LA	March 1991
VFA-303	NAS Lemoore, CA	July 1984
VFA-305	Point Mugu, CA	February 1987
VFC-12	Norfolk, VA	June 1993
VFC-13	San Diego, CA	July 1993

Figure 4-1: Reserve Units Flying the F/A-18, Location, and Transition Date.

between the VFC and VFA Navy units and the Marine units do not affect maintenance and fuel costs.

- Deployments--the unit deployments and detached operations do not affect costs differently. The costs are either consistent with the higher deployment levels of flight operations or the units each deploy approximately equally.

- Home sites--the AVDLR stockage procedures and fuel costs are the same at the various F/A-18 bases across the country.

- Aircraft--either the number of aircraft in each squadron is the same or no squadron has a cost advantage by supporting either more or fewer aircraft while flying the same flight hour program.

- Year-end Goal--the drive to expend 100% of assigned funds while flying 100% of assigned flight hours by 30 September does not affect fuel and maintenance cost performance.

C. FUEL COSTS

Included in Appendix C are the reported flight hours and fuel costs for the ten squadrons flying F/A-18s in the COMNAVAIRESFOR claimancy. Appendix C represents the COMNAVAIRESFOR modified data provided by the units, that is, it is in its cumulative form. To use the fuel costs for comparison purposes, they must first be adjusted for the changes in the fuel contract and inflation. As promulgated by the NAVCOMPT Notice 7111, the contracted fuel prices for FY 1991 through FY 1994 are as noted in Figure 4-2. The notice also provides the price escalation indices for fuel as shown in the figure.

Year:	Fuel Cost:	Index:
FY 1991	$44.52 per barrel	100.00%
FY 1992	$29.82 per barrel	85.20%
FY 1993	$31.50 per barrel	93.38%
FY 1994	$35.70 per barrel	98.05%

Figure 4-2: Annual Fuel Cost and Price Escalation Indices

As can be seen in Figure 4-2, FY 1991 is used as the base year and is therefore assigned an index of 100% (or 1). The following year the cost for fuel dropped dramatically and then began a steady rise in price through FY 1994. Each succeeding index has been computed by NAVCOMPT considering the change in contract price rise and the effect of inflation, so that fuel costs in the follow-on years can be expressed in terms of FY 1991 dollars. To put the costs in term of FY 1991 dollars, the cost of the fuel in a follow-on year is divided by the index for the year in which it was purchased.

Based on the assumptions stated earlier in this chapter, there are no adjustments to be made to flight hours for fuel cost analysis. Though the F/A-18 F-404 engines have varying consumption rates at the various altitudes, aircraft configurations and power settings required for different flight regimes, it is assumed they will be experienced equally by each of the squadrons over the year and will not, therefore, affect the analysis.

For squadrons transitioning to the F/A-18 during the analyzed period, the first six months of fuel cost data is deleted from the analysis. This is because of the potential for higher costs as these squadrons progress through the transition process with higher ground maintenance and pilot training evolutions as they qualify the pilots and gain maintenance expertise on the new aircraft.

The resulting squadron flight hour and adjusted fuel cost data are provided in Figures 4-3 and 4-4, respectively.

Month	Unit	MAG41	MAG42A	MAG46	MAG49A	VFA203	VFA204	VFA303	VFA305	VFC12	VFC13
October	FY 1991	0	0	245	0	139	0	296	266	0	0
November		0	0	487	0	349	0	561	453	0	0
December		0	0	704	0	548	0	779	741	0	0
January		0	0	963	0	805	0	1043	931	0	0
February		0	0	1325	0	1099	0	1340	1178	0	0
March		0	0	1577	0	1370	0	1605	1335	0	0
April		0	0	1856	0	1641	0	1778	1399	0	0
May		0	0	2179	0	1911	73	1987	1592	0	0
June		0	22	2473	0	2090	115	2226	1904	0	0
July		0	59	2793	0	2384	233	2483	2095	0	0
August		0	99	3134	0	2770	356	2834	2359	0	0
September		0	215	3398	0	2967	477	3040	2645	0	0
October	FY 1992	0	114	344	0	229	171	223	254	0	0
November		0	270	651	0	440	358	408	469	0	0
December		0	449	828	0	595	549	631	686	0	0
January		0	694	1056	21	794	666	864	961	0	0
February		0	958	1320	73	1083	866	1042	1214	0	0
March		0	1151	1572	178	1314	1057	1370	1450	0	0
April		0	1287	1886	353	1534	1162	1568	1616	0	0
May		0	1500	2318	713	1936	1495	1729	1811	0	0
June		0	1745	2339	879	2084	1796	1939	1979	0	0
July		0	1901	2540	1026	2201	1910	2158	2200	0	0
August		0	2163	2775	1316	2365	2170	2490	2477	0	0
September		0	2330	2991	1513	2572	2310	2665	2723	0	0
October	FY 1993	15	180	296	209	151	137	216	249	0	0
November		46	481	506	437	379	455	428	441	0	0
December		121	686	726	557	564	669	661	579	0	0
January		193	874	940	818	765	906	839	838	0	0
February		443	1041	1165	1027	1048	1081	1157	991	0	0
March		742	1336	1482	1285	1287	1262	1435	1260	0	0
April		981	1571	1727	1499	1519	1576	1701	1448	0	0
May		1245	1730	2067	1676	1724	1817	2003	1603	0	0
June		1455	2076	2356	1969	2082	2008	2261	1825	19	0
July		1721	2282	2571	2128	2288	2207	2591	2178	38	28
August		1956	2466	2855	2454	2450	2501	2760	2392	87	81
September		2110	2646	2930	2730	2613	2650	2933	2589	236	171
October	FY 1994	269	215	194	205	191	221	182	240	55	41
November		497	470	447	470	452	392	487	408	101	123
December		750	834	621	875	591	850	629	692	157	268
January		1025	828	862	798	711	925	862	863	237	478
February		1255	1032	1067	1013	1003	1120	1097	976	283	871
March		1500	1318	1286	1283	1222	1337	1358	1175	478	920
April		1686	1489	1453	1478	1444	1814	1537	1332	689	1120
May		1864	1646	1749	1599	1593	1791	1799	1590	893	1349
June		2106	1861	2041	2021	1634	2182	2095	1805	1071	1640
July		2336	2175	2236	2226	1936	2444	2122	1835	1377	1981
August		2593	2393	2593	2419	2142	2736	2122	1844	1668	2222
September		2724	2550	2750	2600	2403	3005	2122	1844	1925	2435

Figure 4-3: Squadron Cumulative Flight Hours

Month	Unit	MAG41	MAG42A	MAG46	MAG49A	VFA203	VFA204	VFA303	VFA305	VFC12	VFC13
October	FY 1991	0	0	201635	0	157487	0	290080	297654	0	0
November		0	0	575634	0	387041	0	562122	486975	0	0
December		0	0	806080	0	603896	0	781862	875792	0	0
January		0	0	1018854	0	899185	0	1019011	1031548	0	0
February		0	0	1385950	0	1227583	0	1357420	1278130	0	0
March		0	0	1693698	0	1523440	0	1622655	1516560	0	0
April		0	0	2021184	0	1824792	0	1843488	1475945	0	0
May		0	0	2377289	0	2117388	88403	2052571	1708218	0	0
June		0	17534	2683205	0	2299000	125580	2270520	2096304	0	0
July		0	66375	3128160	0	2622400	245815	2550041	2260505	0	0
August		0	118503	3469338	0	3044230	376648	2899182	2528848	0	0
September		0	258430	3853332	0	3284469	525177	3106880	2782540	0	0
October	FY 1992	0	117211	291108	0	190833	162370	193685	258174	0	0
November		0	266514	582232	0	375962	327746	344789	409549	0	0
December		0	430555	734704	0	516086	491651	528055	583744	0	0
January		0	650829	935775	17845	709195	600338	737239	790682	0	0
February		0	821946	1154225	55350	994021	748094	894016	990293	0	0
March		0	1099664	1359817	137887	1187535	934180	1169002	1181103	0	0
April		0	1241683	1591589	268065	1380960	996974	1323230	1325803	0	0
May		0	1375000	1787472	550650	1742854	1312512	1455039	1464529	0	0
June		0	1597535	1954657	689169	1868751	1585202	1645419	1637553	0	0
July		0	1827370	2161385	836937	1971083	1699272	1826195	1848826	0	0
August		0	2061451	2403697	1065775	2117952	1958603	2127606	2067074	0	0
September		0	2212406	2615370	1255506	2267103	2071408	2274008	2294735	0	0
October	FY 1993	11164	151703	267852	168086	120632	88761	170709	228521	0	0
November		32217	387870	470887	371108	308054	337669	379507	366004	0	0
December		80338	561994	667845	462874	465067	493619	554255	473096	0	0
January		141784	696355	864703	672761	636544	687892	706205	684723	0	0
February		328763	849477	1061700	840253	893348	846232	997414	825656	0	0
March		588801	1117387	1341069	1052715	1094322	1001437	1218628	1052474	0	0
April		765848	1335804	1566469	1261741	1283456	1338368	1466379	1173845	0	0
May		1011946	1487674	1815100	1417905	1467745	1544975	1711709	1308081	0	0
June		1213798	1780762	2056265	1865785	1797057	1720283	1861972	1481420	16786	0
July		1481778	1893928	2249419	1736492	1967513	1893132	2169803	1807614	33572	26057
August		1686207	2073046	2500953	2126029	2109445	2099790	2308374	1972414	78354	75726
September		1807668	2247031	2579203	2318366	2255384	2264618	2462489	2134858	186263	164444
October	FY 1994	204391	187042	187965	188169	189539	205786	160932	142703	40107	38303
November		407028	384437	423978	403610	414890	376208	449997	381161	85703	115285
December		810403	620098	594716	619582	606973	814533	576075	623188	138346	239710
January		836308	808999	848373	720275	718439	919811	778042	766622	224793	444687
February		1103325	1009371	1052309	901937	947249	1096583	993509	853067	274197	624807
March		1392147	1264904	1278786	1177664	1160308	1304956	1218807	1021010	462158	858542
April		1597444	1418384	1493752	1386803	1371100	1600008	1316757	1172377	668270	1076022
May		1754688	1554509	1719568	1501967	1515828	1791913	1577909	1407568	867043	1271266
June		2003976	1753762	2021225	1809728	1558174	2152078	1839669	1605263	1030039	1533789
July		2253805	2051887	2253104	2013730	1871829	2412842	1843900	1654401	1306079	1872000
August		2467383	2230701	2552009	2225332	2053524	2673218	1861214	1628663	1593999	2091694
September		2630931	2418664	2698113	2444875	2291489	2911525	1867706	1628663	1818001	2317037

Figure 4-4: Squadron Adjusted Fuel Costs (FY 1991 Dollars)

D. ORGANIZATIONAL MAINTENANCE ACTIVITY (OMA) COSTS

Organizational Maintenance Activity (OMA) costs are incurred by the squadrons when squadron personnel conduct local maintenance actions. Maintenance activity at the squadron level can be categorized into two primary components:

- Scheduled preventive maintenance
- Unscheduled reactive maintenance

These components may have an impact on any or all three levels of maintenance action, but they are the primary purposes of OMA maintenance.

The preventive maintenance is scheduled on a cyclic basis. Different maintenance requirements, such as cleaning, lubrication and inspection actions, are due on 90, 128, or 244-day cycles for instance. Other maintenance requirements may be based on the actual number of flight hours experienced by the aircraft or the number of occurrences of a specific event. Some maintenance inspections and maintenance actions may be required after a certain number of overweight landings or a specified number of arrested landings for instance. These actions may lead to the discovery of equipment malfunctions in need of minor additional maintenance efforts or significant equipment replacement and overhaul requirements, affecting higher levels of maintenance. Significant equipment replacement usually necessitates the additional cost and assistance from Intermediate level or Aviation Depot Level maintenance activities.

The preventive maintenance requirements can be anticipated in advance; however, the unscheduled maintenance requirements make planning and budgeting more difficult. Military aircraft are highly complex, interactive, mechanical, hydraulic and electronic systems in a dynamic, high-stress environment. With even the best preventive maintenance

practices conducted by the highest trained personnel, the equipment will fail seemingly without warning. In an effort to predict high failure items and equipment of poor design, maintenance trends are tracked and reported to the Aviation Supply Office (ASO).

Maintenance trends or equipment/system failure analyses are conducted primarily for the safety of the aircrews, but they also have a tremendous impact in maintenance planning and cost budgeting. Maintenance trend analysis and the resultant life cycle adjustments have greatly impacted the F/A-18 Intermediate Level and Aviation Depot Level costs discussed in the next two sections.

Like their Naval Reserve counterparts, some Reserve Marine Corps F/A-18 units augment their organizational level maintenance activities with Marine Aviation Logistic Squadrons (MALS) or other active duty Marine squadrons. These units are dedicated maintenance supply and squadron support or assist by assuming some of the OMA maintenance actions. In an effort to lessen the paperwork and part tracking load, they will also sometimes transfer a part of the reserve costs onto other active duty units by charging them for work done in support of the Reserve unit. MAG-46 in San Diego, CA is assisted by MALS-11, at Marine Corps Air Station El Toro, CA. Without a MALS readily available, the East Coast Marine F/A-18 squadrons, MAG-42A in Jacksonville, FL, and MAG-49A in Washington, D.C., use an active duty counterpart, MAG-31, at Marine Corps Air Station Beaufort, South Carolina in much the same capacity. The exact effect, nature and breakdown of the costs inadvertently transferred between the active duty and reserve aviation units by the supporting units cannot be precisely determined, but both OMA and some IMA costs are affected to some degree.

Like the fuel costs in the previous section, the OMA costs as reported by the squadrons are modified by

COMNAVAIRESFOR to their cumulative Cost Per Hour (CPH) form. Again, they must be adjusted for comparative purposes and, for the purpose of consistency in the analysis, FY 1991 is used as the base year. To prepare for the adjustment, the monthly costs per hour are multiplied by the cumulative number of flight hours reported for that month. This results in the total OMA cost for the month. Then to compare across the different Fiscal Years (FYs), the cumulative monthly costs in FY 1992, FY 1993, and FY 1994 are each adjusted by multiplying by an inflation adjustment index from the NAVCOMPT 7111.

The indices from the NAVCOMPT 7111 [Ref. 21] which were used are:

FY 1992	FY 1993	FY 1994
1.026	1.0506	1.0748

The resulting inflation adjusted (to FY 1991), cumulative monthly OMA cost data is provided in Figure 4-5.

E. INTERMEDIATE MAINTENANCE ACTIVITY (IMA) COSTS

Intermediate Maintenance Activity (IMA) costs are incurred when aircraft system components fail and require maintenance techniques and procedures unavailable at the squadron level. Whereas the squadron maintenance effort and OMA costs are primarily for "consumable" maintenance parts and supplies, IMA costs are generally incurred for items and system components considered to be economically repairable. Therefore, maintenance procedures and capabilities requiring the aid of specialized tools are obtained and systemized into maintenance "work benches." These capabilities, or "benches," are maintained by a centralized IMA facility, the Aircraft Intermediate Maintenance Department (AIMD), as a part of aircraft base support for the squadrons. In addition to the savings from repair vice replacement, the centralization of these capabilities adds the dimension of "economies of scale" to the maintenance effort.

Month	Unit	MAG41	MAG42A	MAG46	MAG49A	VFA203	VFA204	VFA303	VFA305	VFC12	VFC13
October	FY 1991	0	0	980	0	37947	0	31080	3724	0	0
November		0	0	4383	0	86203	0	83028	166251	0	0
December		0	0	6336	0	145220	0	122303	160797	0	0
January		0	0	54891	0	214130	0	196084	280231	0	0
February		0	0	58300	0	287938	0	191620	359290	0	0
March		0	0	63080	0	365790	0	258405	413850	0	0
Apnl		0	0	92800	0	405327	0	296592	498044	0	0
May		0	0	100234	0	494949	133663	333816	600184	0	0
June		0	92862	103866	0	549670	176870	380646	656880	0	0
July		0	110920	106134	0	810304	204574	451906	750010	0	0
August		0	142263	106556	0	686960	228196	467810	816214	0	0
September		0	179095	112134	0	726915	250425	535040	878140	0	0
October	FY 1992	0	55444	1006	0	54237	59000	62162	58425	0	0
November		0	111316	12056	0	75478	95257	94246	149934	0	0
December		0	157981	12912	0	114825	162132	134072	215294	0	0
January		0	204277	18526	81544	178766	231737	220632	221049	0	0
February		0	241834	19298	126078	219556	261657	225462	294626	0	0
March		0	287189	26047	230047	265105	429599	272398	357554	0	0
Apnl		0	426491	29411	336829	337899	618374	316351	396912	0	0
May		0	447368	31630	400976	366066	540590	338722	432451	0	0
June		0	484722	36476	532026	420456	596916	368523	499572	0	0
July		0	563259	64366	689000	461223	832943	433283	568226	0	0
August		0	592401	45980	711871	511725	666228	473246	601143	0	0
September		0	644951	46643	603135	541474	760994	490921	644921	0	0
October	FY 1993	24757	108452	1690	55702	68271	59072	94575	86982	0	0
November		47200	117205	3371	92757	106420	86184	107957	138521	0	0
December		70140	208294	4146	116108	146019	132450	145966	154863	0	0
January		94424	300318	5368	147935	211893	198344	219613	222541	0	0
February		137462	348784	7762	173024	249381	246945	262104	267889	0	0
March		166678	409473	8464	237283	308704	303908	307324	346602	0	0
Apnl		197955	512900	16438	298202	368689	409526	359435	434152	0	0
May		226342	596097	17707	373295	433215	435831	434889	501986	0	0
June		301913	620468	22425	412317	455797	485467	505744	541976	73352	0
July		332537	679865	29366	552964	511784	506270	537634	576322	72810	0
August		355603	699475	40762	593295	559680	559428	567447	680761	73784	0
September		459918	750531	44622	636636	604377	592757	555556	722042	149381	89032
October	FY 1994	77837	39407	541	51689	62198	87238	71459	89989	24409	35629
November		115140	102326	4575	101889	98407	109418	132761	146528	85702	36964
December		173753	147469	7511	130001	118222	149981	157426	172549	159366	66077
January		226019	249602	8822	175221	170672	182453	178046	236867	201102	100532
February		273232	275571	9927	221488	214635	256345	194945	297849	278313	141717
March		330759	307795	15555	335433	247856	279889	223638	348739	280627	213993
April		343537	358812	17574	379539	290197	309345	254546	412687	372450	280313
May		374604	395114	19527	391270	327552	373264	279525	470432	401302	293697
June		391887	457112	24686	402395	378550	436504	333313	520608	465349	338742
July		447726	524121	27045	426643	399881	450234	335635	554871	518873	357607
August		528347	547709	31363	490642	454388	547302	361301	566170	600592	374192
September		527160	640584	35821	510421	511990	617887	363275	566170	823874	432718

Figure 4-5: Cumulative Inflation Adjusted Monthly Organizational Maintenance Costs (FY 1991 Dollars)

To illustrate this concept with a typical example, personnel at the squadron level are tasked with replacing aircraft tire and wheel assemblies when the tires are worn out of acceptable safety limits. Good assemblies are taken from supply and the worn tires and wheels sent to AIMD for repair. The AIMD maintains the tools and expertise to break down the assemblies and replace the tire. When the repairs are complete, the assemblies are maintained in a centralized base supply as spares, and categorized as Ready For Issue (RFI).

The squadron's IMA cost pool is charged for the repair of a part when it is turned into AIMD and the replacement is taken from supply. The cost charged to the squadron becomes more complicated, however, if a replacement part is not available from supply and the item is Beyond the Capability of Maintenance (BCM) for repair at the AIMD level. In these instances, the malfunctioning component, called a carcass, is forwarded to a Naval Aviation Depot or, in some cases, back to the original contractor for specialized inspection and repair, or replacement. In this situation, the squadron's Aviation Depot Level Repairable (AVDLR) cost pool is charged for the replacement/repaired part. Because the AVDLR charges are generally much higher than the rates charged for IMA and because of significant delays in getting the part returned, reserve squadron maintenance managers, like many of their active duty counterparts, will usually form a close working relationship with the local AIMD Maintenance Officer and track their repairable parts through the AIMD repair process. If the part will be BCM'd at the local AIMD, but the capability for repair is confirmed to exist at another base, whenever possible the managers may elect to transport the part to the other repair facility. Squadron maintenance managers will do this to expedite the repair and return of the part and control the cost of its repair. [Ref. 22] In any case, items at this level can take as much as six months to fix and therefore may

result in time lags of one to six months, or more, in the final cost of repair determination.

For reserve squadrons at smaller bases with limited support, this fluid aspect of the Intermediate level maintenance system capability and cost structure causes the unit's IMA costs to fluctuate more than any other pool of costs. The IMA cost pool depends, more than any other cost pool, on the repair capability of the host base and the management ability of the squadron maintenance officers and their ability to influence their base support. For the reserve units at the larger active-duty bases however, the relationships with base support and active duty units have even more profound results which will be discussed in Chapter V.

To prepare the IMA cost data for the analysis, it was treated much the same as the Organizational Maintenance Activity (OMA) data. That is, the COMNAVAIRESFOR cumulative IMA cost per flight hour information for each unit was multiplied by the cumulative number of flight hours to obtain the total accumulating monthly IMA costs. These figures were then translated into constant year FY 1991 dollars. This was accomplished by dividing each year's data by the same inflation indices from the NAVCOMPT 7111 Notice that were used for the OMA cost pool and in the same manner.

As a final additional adjustment, each month's costs were modified for the annual percentage change in the charges for the Defense Business Operations Fund and its predecessor, the Navy's Revolving Funds (stock fund and industrial fund). These factors were also computed by the Navy Comptroller and promulgated in the NAVCOMPTNOTE 7111. [Ref. 23] DBOF industrial fund activities were established to serve the operating forces on a revolving fund, reimbursement basis. It collects all the costs of doing business and passes them onto their customers, in this case, the F/A-18 units. Maintenance

rates are set and charged based on a prediction of the year's level of business. The funds needed for conducting business are taken from a revolving fund to be reimbursed by payments from the customers as the work is completed. If the rates set at the beginning of the year are incorrect, then the fund is depleted or grows and the rates must be changed to attempt to maintain a balanced level. The F/A-18 data must be adjusted for this change in rate.

To illustrate, VFA-305's May 1994 IMA cost was found and modified as follows:

$$\frac{(\$308 \text{ per Hr})(1590 \text{ Flt Hrs})}{(1.0748)(1.012*1.104*1.06)} = \$384{,}738$$

Where:
1.0748 = The adjustment for inflation (to FY 1991)
1.021 = The change in the FY 1992 DBOF rate (to FY 1991 dollars)
1.104 = The change in the FY 1993 DBOF rate (to FY 1992 dollars)
1.06 = The change in the FY 1994 DBOF rate (to FY 1993 dollars)

Figure 4-6 contains the adjusted IMA cost data for all 10 Navy Reserve F/A-18 squadrons for FY 1991 through FY 1994. The regression analysis will use this data with the flight hour data presented in Figure 4-3 to attempt to define the relationship between this cost pool and the flight hours flown.

F. AVIATION DEPOT LEVEL REPAIRABLES (AVDLR) COSTS

Aviation Depot Level Repairable (AVDLR) cost is incurred when a part or component is Beyond the Capability of Maintenance (BCM) at the intermediate, IMA, level. The AVDLR cost pool is used when the component is sent to a specialized repair depot, a NADEP, or the original contractor for repair or replacement. At this level of repair, like the IMA level, the cost of repair and replacement can fluctuate widely. For

Month	Unit	MAG41	MAG42A	MAG46	MAG49A	VFA203	VFA204	VFA303	VFA305	VFC12	VFC13
October	FY 1991	0	0	13230	0	14873	0	47952	7980	0	0
November		0	0	180190	0	37343	0	49929	58890	0	0
December		0	0	393536	0	53704	0	77121	44460	0	0
January		0	0	402534	0	67620	0	84483	81928	0	0
February		0	0	596250	0	103306	0	139360	150784	0	0
March		0	0	657609	0	152070	0	165315	300375	0	0
Apnl		0	0	688576	0	155895	0	237984	352548	0	0
May		0	0	878137	0	179634	84023	282154	420288	0	0
June		0	128788	971889	0	254980	113275	333900	691152	0	0
July		0	107380	1041789	0	290848	122092	350103	670400	0	0
August		0	72963	1109436	0	343480	136704	385424	757239	0	0
September		0	35045	1236872	0	629004	167904	635360	894010	0	0
October	FY 1992	0	24484	68912	0	30215	7411	28135	34248	0	0
November		0	85292	119126	0	46614	14826	38509	220879	0	0
December		0	86054	196172	0	142115	120025	101489	352147	0	0
January		0	178461	286804	26576	181999	186655	139796	432228	0	0
February		0	223282	359776	62151	264932	206843	215764	604479	0	0
March		0	205078	484479	94459	320175	227014	283682	645182	0	0
April		0	250381	628478	105732	381169	313355	431901	874681	0	0
May		0	281707	714390	147639	402746	326843	452935	1001158	0	0
June		0	354609	853771	165927	485719	449730	489273	1092125	0	0
July		0	443067	1338114	192688	534186	487474	594415	1218324	0	0
August		0	524964	1411137	195186	699265	631159	673873	1350251	0	0
September		0	742773	1463364	215662	797625	671879	947100	1518442	0	0
October	FY 1993	5930	41251	24209	20120	54802	92440	9201	5728	0	0
November		8583	81548	169417	37230	112042	116291	65999	74766	0	0
December		16494	113381	214006	47928	134540	206323	30409	194845	0	0
January		29432	167536	406822	84324	234626	365092	135809	127080	0	0
February		52838	208416	433731	115493	285709	403379	137999	156192	0	0
March		89765	268616	499984	126991	353059	412861	184604	234013	0	0
April		117007	343971	622366	306497	421879	482018	284036	345414	0	0
May		260926	417105	656844	371245	480284	517028	288390	361903	0	0
June		290063	454541	732624	387499	560507	538874	414145	385379	12189	0
July		319632	480762	792910	422416	561386	601680	485761	424919	24378	13335
August		408270	495813	882929	434861	563564	713792	569033	450367	51291	38782
September		476367	532004	938574	502377	609962	785666	574716	489664	26942	82602
October	FY 1994	54101	38849	26215	22548	43216	72575	45898	32431	12358	1127
November		77310	108189	60051	170960	84870	95162	228030	100648	18806	16041
December		96043	93142	92696	252953	140685	180773	295013	98401	25409	46531
January		124817	147663	132733	261430	222874	210745	346732	131531	34260	57218
February		141979	209178	195316	284911	392416	234934	360247	181725	36463	95415
March		172053	332382	280868	381009	513620	380239	412884	208623	39055	222616
Apnl		360283	360298	299078	361120	560417	412101	519229	312890	55754	266611
May		396855	411220	453441	391940	642022	437596	580885	384738	82785	196065
June		466578	481016	439350	404877	793336	587691	656710	426836	72361	262840
July		607480	550214	541052	494913	800033	814424	696849	462762	137390	317387
August		745591	560242	692625	581533	900306	664189	758864	514288	145457	338659
September		785398	645079	725920	655685	993016	722408	758864	563543	293393	353906

Figure 4-6: Cumulative Inflation Adjusted Monthly Intermediate Maintenance Costs (FY 1991 Dollars)

instance, replacing a component without a carcass, especially if the replacement part is new from the contractor, can be much more expensive than a repair of the carcass (the used, broken component). Therefore, costs at this level also depend heavily on the management ability of the maintenance officer to track the components in need of repair and ensure that the most economical avenues are used to return mission essential parts and supplies.

Tracking malfunctioning components through an AIMD then through the AVDLR pipelines can be a daunting task. The active duty bases and the reserves, both Naval Air Reserve units aboard active duty bases and the stand-alone Naval Air Facilities, have separate part tracking systems. These systems rarely communicate and the potential for a lost or delayed part and incorrect charges to the unit's AVDLR account are common. The Naval Air Facilities, frequently located a fair distance from the repair facilities, must ship their parts and await their return, creating time lags, complicating part tracking and prolonging the repair process.

Depending upon the criticality of the component, the depots may also hold onto the carcasses, waiting for an economical number of them to repair in a batch process. In the interim, the squadron is usually billed the price of a replacement, to be modified downward when the repairs are completed and costs accurately determined. These lags and price changes all complicate the process of assigning a specific cost to a given month and the associated flight hours flown for that month.

Because of the consistent nature of Reserve flight operations the lags would normally be assumed to average out over the period of the analysis. Beginning in March 1992, however, major changes were made to the engine life cycle limitations for the F/A-18 F-404 engine and its component parts. Because of these changes, the reserve units supported

by the Naval Air Stations had to remove more components more often because they had already exceeded the new life-cycle limitations. The components of the F-404 engine were already making up the majority of the squadron AVDLR costs and, during a period of fiscal austerity, the sudden increase in costs due to the engine life reductions resulted in the budget shortfalls that are still a part of COMNAVAIRESFOR's budgeting problems. The projected FY 1995 budget shortfalls amounted to over $40 million and are primarily attributable to the increase in AVDLR costs. [Ref. 24] Table 3-1, a brief synopsis of the engine life cycle changes for the fiscal years 1992 through 1994 was provided in Chapter III.

The effects of the engine life-cycle changes on the AVDLR cost pool were so severe that the method for preparing the regression analysis data was changed. The effect of inflation on the cost pool is still considered, however the costs are then adjusted for the net effect of the engine life changes in addition to the increased charges in the DBOF.

To prepare the data provided by COMNAVAIRESFOR and recorded in Appendix C, the cumulative AVDLR costs were multiplied by the cumulative flight hours for that month. This resulted in the total cost charged to the unit's AVDLR cost pool for that month. In order to compare these multi-year costs to each other, again, requires an adjustment for inflation. Dividing by the inflation indices provided by NAVCOMPT Note 7111 and used for the OMA and IMA costs changes the costs to constant year dollars. Again, the base year selected was FY 1991.

To obtain the costs shown in Figure 4-7 required modifying the constant year dollar figures for two primary additional effects: 1) the annual increase in the Defense Business Operating Fund charges, or when available the increased rate for engine repair, and 2) the increased use of depot level maintenance due to the engine life-cycle

Month	Unit	MAG41	MAG42A	MAG46	MAG49A	VFA203	VFA204	VFA303	VFA305	VFC12	VFC13
October	FY 1991	0	0	67375	0	98968	0	59792	41496	0	0
November		0	0	202592	0	240112	0	212058	273159	0	0
December		0	0	432960	0	320032	0	335749	203034	0	0
January		0	0	507501	0	406525	0	465178	515774	0	0
February		0	0	719475	0	541807	0	576200	823422	0	0
March		0	0	738036	0	779530	0	694965	768960	0	0
April		0	0	838912	0	869730	0	907536	1166766	0	0
May		0	0	1263820	0	945945	41318	1031253	1330912	0	0
June		0	198484	1394772	0	1118150	88090	1237656	1591744	0	0
July		0	165613	1293159	0	1268288	230437	1340820	1573345	0	0
August		0	181962	1614010	0	1457020	298328	1666392	1896636	0	0
September		0	198660	1773756	0	1646685	323883	1836160	2258830	0	0
October	FY 1992	0	90731	102242	0	100128	105818	168417	231755	0	0
November		0	181473	167610	0	193180	203750	239578	548677	0	0
December		0	272577	264794	0	607930	333285	342023	690992	0	0
January		0	420057	456955	33693	720159	477113	396508	888991	0	0
February		0	525325	683286	125564	943148	556239	543147	902595	0	0
March		0	834278	791010	149386	1018490	616853	540849	1112115	0	0
April		0	826651	971160	187511	1353923	901724	790414	1242353	0	0
May		0	917390	1118224	247984	1477870	983211	1066817	1848720	0	0
June		0	1209108	1276266	441507	1611557	1377489	1226168	1802107	0	0
July		0	1373872	1475431	474560	1803439	1321710	1477729	2158374	0	0
August		0	1612073	1606923	577785	1841673	1729030	1857834	2235454	0	0
September		0	1925977	1702281	684780	2100456	1838493	1824906	2472224	0	0
October	FY 1993	2815	122958	117572	38467	174550	245174	42898	20469	0	0
November		43001	183006	273501	98551	338576	272746	238502	247671	0	0
December		70772	495057	397167	129260	316749	534863	400077	499554	0	0
January		151916	648531	538856	300513	932170	914163	557863	721796	0	0
February		229780	780022	778014	460225	1159604	998731	874516	759139	0	0
March		489587	1015645	1002652	623517	1420310	1259600	1067939	1234688	0	0
April		513831	1337153	1285248	799327	1706177	1603958	1351282	1613788	0	0
May		827656	1549256	1341295	1036363	1945217	1718373	1468793	1773707	0	0
June		772689	1807759	1374576	1200352	2287056	1951593	1792859	1979518	18425	0
July		888911	1806191	1561736	1359206	2285312	2008532	2261870	2440044	18411	17457
August		1052979	1856746	1715557	1438893	2336619	2101429	2889275	2632808	69683	50735
September		1112857	2178990	1826701	1640445	2395129	2313376	2946624	2627395	123613	75759
October	FY 1994	69526	85423	102350	19869	107397	126880	151941	106079	14858	29790
November		83359	206607	142572	309023	280876	200542	564242	290694	28430	30438
December		106461	285673	204259	444737	398939	459770	772217	401948	70149	64846
January		140916	373087	275233	508225	663463	549921	886137	514621	98481	105849
February		185477	566096	294114	697725	1089345	648595	933921	596429	124307	196720
March		263960	744723	346967	709953	1215058	848172	1071173	732172	199117	220709
April		544127	839297	435471	723880	1243232	895178	1225045	857929	256463	332590
May		556728	922701	629381	889210	1492516	1128879	1488898	1042684	290656	440930
June		715143	1078403	810219	1281563	1844866	1278511	1278085	1248818	360003	540555
July		973089	1208031	946035	918852	1859127	1389855	1402497	1292907	390450	646359
August		1274430	1320064	1212045	1031775	2028236	1547231	1490016	1358823	412788	713293
September		1369710	1429458	1363881	1078594	2160572	1687098	1515543	1365795	396310	1001776

Figure 4-7: Cumulative Inflation, Life-cycle and DBOF Rate Adjusted Aviation Depot Level Repairable Costs

decreases. Considering the cost of the engine life-cycle limitations, deducting their cost impact allows a better comparison of the costs before and after the engine life-cycle changes. Since the life-cycle changes are not temporary, the analyst may decide to include the life-cycle costs in the final model. Should this be the case these operations should not be done to estimate future costs. However, for comparison purposes, the final total costs should include consideration of the engine life-cycle limitations.

To perform these mathematical adjustments, the assumptions made and factors considered were that:

- The engines, already the largest cost in the AVDLR pool, with the decreased life-cycle times, had in effect become the AVDLR pool.
- Non-engine related components stayed consistent in repair frequency over the four years.
- Like the other cost pools, percentage increases in the DBOF charge rates are applied equally to all parts and components inducted into the system.

To calculate the impact of the life-cycle reductions, the percentage decrease in each subcomponent of an engine component's life-cycle was found. This decrease was then multiplied by a fraction describing its occurrence during the fiscal year to give the annual net effect of the change on subcomponents life-cycle. The subcomponents, within an engine component, were then combined based on the percentage of the original hourly life-cycle. This resulted in an annual life-cycle change, in percent, for a specific engine component. To illustrate, the First Stage (subcomponent) of the engine Fan section (major component) decreased, in June 1992, to 2700 hours between maintenance actions from the original 5850 hours. Therefore, the net life-cycle effect is:

$$\frac{(5850 \text{ hrs} - 2700 \text{ hrs}) * (3 \text{ months left in FY})}{(5850 \text{ hrs}) \; * \; (12 \text{ months in the FY})} = 13.46\% \text{ effect of change in hrs}$$

The 13.46% is then multiplied by the original percentage of the total component hours between maintenance actions to weight it. These weighted percentage changes in subcomponent life-cycles were then added to obtain the change in life-cycle for the component. To continue the illustration:

$$\frac{(13.46\%)(5850\text{ hrs})}{(5850 + 8770 + 4380 + 9030)} + 8.87\% + 4.07\% + 0 = 15.75\%$$

For the next fiscal year the effect is modified for the number of months it is in effect in that year. If the subcomponent does not have another life-cycle reduction then the previously computed annual reduction carries through for the entire year. With a subsequent life-cycle reduction, the new reduction effect based on the original hours is computed for the portion of the year that it affects and is added to the previous percentage reduction to determine the net effect over the entire fiscal year.

After finding the percentage change in each component's life-cycle for a given year, they are weighted based on original cost for the component, then added together for the net percentage change in the F-404 life-cycle. The original cost of the components was used to weight the changes based on the assumption that the cost ratios were a good predictor of relative component complexity and importance to the F-404 engine life-cycle performance. The data provided by COMNAVAIRESFOR is then divided by one plus the computed percentage for the given year to modify the cost pool for the cost effect of decreasing the engine subcomponent life-cycles.

The final aspect of the AVDLR cost pool to be considered is the change in the DBOF rate for work performed. The NAVCOMPT 7111 provides the percentage rate increases over the prior year for AVDLR level work performed. These rates, however are not specific to the F/A-18. In an in-house

Aircraft Intermediate Maintenance Department, Naval Air Station Cecil Field report, it was noted that the AVDLR costs to repair an engine rose from an average of $74,000 in FY 1993 to $136,000 in FY 1994. [Ref. 25] This is an increase of approximately 87% and was used to modify the FY 1994 data to FY 1993, then the percentage rate increases promulgated via the NAVCOMPT 7111 were used to account for cost increases in the process of translating to FY 1991 dollars.

G. SUMMARY

In this chapter, the four cost pools: Fuel, Organizational Maintenance Activity, Intermediate Maintenance Activity, and Aviation Depot Level Repairables, were described. The data provided by Commander Naval Air Reserve Force, New Orleans for ten Navy and Marine Corps reserve units flying the F/A-18 from FY 1991 to FY 1994 were mathematically prepared for the next step: regression analysis.

The data was first modified for the effect of inflation. Since 48 months of data formed the database, the costs in subsequent years were deflated to their FY 1991 value. In the case of fuel costs, which are determined by an annual contract, the adjustment was for the difference in the contract. The effect of inflation was included in the contracted costs. Each maintenance cost pool was then adjusted for identifiable changes in DBOF rate changes and engine life-cycle changes as identifiable and appropriate to enhance the comparability of the data between the years.

One final aspect of aircraft operations that could not be defined in the first two cost pools, but which does have an effect, is the increased life-cycle costs. As the aircraft ages, there is an increase in maintenance costs at the OMA and IMA levels, just as at the AVDLR level. As the engines age, increased fuel consumption as a result of falling fuel efficiencies may even have an effect on costs.

The goal of modifying the data explained in this chapter was to prepare it for analysis. For the analysis to provide usable results, any and all external forces and trends affecting the costs not related to the independent flight hour variable need to be mathematically deleted. In this manner the effect of flight hours on the costs can be identified. This analysis is the purpose of Chapter V.

V. DATA ANALYSIS

A. INTRODUCTION

In this chapter, the cost data provided by Commander Naval Air Reserve Force (COMNAVAIRESFOR) is analyzed using the method of regression analysis. Section B of this chapter describes the output from the regression analysis program and its usefulness for defining the relationships between the data. The following section delineates the analysis of the fuel cost data and describes the results of its analysis. The next sections are then devoted to each of the individual maintenance cost pools reported to COMNAVAIRESFOR, discussing the regression outputs for each, their meaning and usefulness. Any necessary assumptions and data characteristics impacting the analysis are noted in the applicable data section. The final section provides a chapter summary.

B. REGRESSION OUTPUTS

For each regression operation seven outputs are available from the Lotus spreadsheet program. These outputs are important for judging the degree of fit of the regression line to the observations and for writing the regression equation. The seven outputs are:

- The Constant: The point where the regression line crosses the Y-axis, (B_o).

- The Standard Error of the Y Estimate: The square root of the sum of the squared differences between the estimated Y value represented by the regression line and the observed value, (Y_o - Y_e), divided by the number of degrees of freedom.

- R-Squared (R^2): An indication of fit, this value indicates how much variation in the dependent variable is explained by the independent variable.

- Number of Observations: The number of data pairs in the analysis.

- Number of Degrees of Freedom: The number of data pairs minus the number of independent variables.
- The X Coefficient: An indication of the slope of the regression line. Positive is upward sloping and negative downward sloping. The higher the coefficient the steeper the slope, (M).
- Standard Error of the X Coefficient: The square root of the sum of the squared differences between the observed data point and the regression line divided by the degrees of freedom.

The precepts of linear regression analysis used to model the ties between flight hours and costs are based on the assumption of a linear relationship. If the relationship is in fact curvilinear over the range being analyzed, there is almost no limit to the number of equations that can be used to describe the data. The equations may be defined as parabolas or hyperbolas in their simple form, cubic form, or any of a myriad of combinations. For the purpose of simplifying the analysis, the data will be assumed to be linear over the range of the data being analyzed. Visual analysis of the data is the easiest method for confirming this assumption. Also a poor R^2 is an indicator that the assumption may not be true.

Assuming the relationship is linear, the equation:

$$Y_o = MX_o + B_o$$

describes the relationship between the independent value, X, and the dependent value Y. The X value represents the number of flight hours and the Y value the corresponding cost. This "basic" linear equation can then be modified for the difference in the actual, or observed, value of the dependent variable (Y_o) and the expected value from the regression line (Y_e):

$$(Y_o - Y_e) = MX_o + B_o - Y_e$$

The difference in the Y values is also known as the deviation error term or the residual. [Ref. 26: p 3] The standard deviation of the differences in the observed costs is provided as the Standard Error of the Y Estimate. It and the Standard Error of the X Coefficient can be used in simple equations to aid in determining the degree to which the regression equation quantifies the relationship between the variables.

The degrees of freedom (i.e., the number of observations less two) is also used in a number of equations to evaluate the regression equation. It implies that, for simple (two variable) regression analysis, two degrees of freedom are used in constructing the regression line leaving the rest to explain the variance in the equation. This is because with just two points a perfect regression line, going through both points, can be described. [Ref. 27: p. 32]

The coefficient of determination, or R^2, is the only output immediately usable for determining the degree of fit described by the regression equation. It is expressed as a percentage and describes the proportion of variation in the dependent variable that can be explained by the independent variable within the context of the regression equation. [Ref. 28: p. 11] Therefore, the closer the value of R^2 is to one (100%), then the better the fit between the dependent and the independent variables. This implies that the resulting regression equation, constructed from the X coefficient and the Y-axis intercept, is representative of the relationship between the variables.

C. FLIGHT HOURS VERSUS FUEL COSTS

As described in Chapter IV, Figure 4-3 contains the cumulative number of flight hours flown by the end of each month for the ten squadrons. The following figure, Figure 4-4, lists the adjusted, cumulative fuel cost data, on a monthly basis, for each of the units. This adjusted fuel cost was

found by dividing the reported fuel cost (from Appendix C) by the appropriate annual index listed in Figure 4-2. Since FY 1991 was the base year, no calculations were required for the information in this year. For example, MAG-46's October 1991 (FY 1992) fuel cost of $248,024 (reported by COMNAVAIRESFOR as 344 flight hours with fuel costs of $721 per hour) was adjusted as follows:

$$\frac{(344\ \text{Flt Hrs}) \text{X} (\$721\ \text{per Hour})}{(.8520\ \text{Cost Escalation Index})} = \$291{,}108 \text{ in FY 1991 terms}$$

These calculations were accomplished for each of the costs in Figure 4-4. The result is a table containing the monthly cumulative fuel costs for each squadron in terms of FY 1991 dollars. Given the assumptions listed, these costs can be used for regression analysis.

The regression program was run with the flight hours as the independent variable along the X-axis and the fuel costs as the dependent variable on the Y-axis. Except for the number of degrees of freedom and the number of observations, the output generated by the spreadsheet program is summarized in Table 5-1.

The coefficient of determination, R^2, values range from 1.000 to .938 indicating a high percentage of the variation in the cost of fuel is caused by the change in flight hours. The

FUEL COSTS VERSUS FLIGHT HOURS

Unit:	Constant	Std Err of Y Est	R Squared	X Coef	Std Err of Coef
MAG41	-149320.56	76655.64	0.989	994.44	26.77
MAG42A	-1582.60	85342.15	0.984	906.56	20.51
MAG46	-22571.93	205643.62	0.950	971.54	33.02
MAG49A	-26864.59	70070.63	0.989	891.54	18.43
VFA203	-25211.68	164601.03	0.959	973.41	29.80
VFA204	-49262.69	105991.15	0.981	936.43	22.85
VFA303	-16293.19	136900.64	0.968	912.69	24.29
VFA305	1971.25	166812.57	0.938	901.95	34.12
VFC12	5168.25	10722.89	1.000	949.10	5.74
VFC13	-10714.15	13477.13	1.000	952.50	6.90

Table 5-1: Regression Output for Flight Hours Verses Fuel Costs

average of .976 implies that only 2.4% of the variation in fuel costs is a result of other causes. These unknown variations may be caused by the different engine efficiencies for the different missions and the fuel used for ground maintenance operations which does not add to the flight hour total. In addition, there are mathematical variances induced by purchasing non-contract fuel at significantly higher prices. Finally, the average is improved by the data from the two VFC squadrons. The low number and relative consistency of the observations for these two units resulted in 1.00 for their coefficients of determination. All the data from these two units are from the same Fiscal Year, FY 1994, and are unaffected by outside influences such as Desert Storm, fuel price hikes, and the like which tend to cause willful manipulation of flying habits (operational tempo) and fuel purchases to meet year-end budgets.

D. FLIGHT HOURS VERSUS OMA COSTS

Table 5-2 summarizes the results, minus the number of observations and the degrees of freedom, of the regression analysis of flight hours and Organizational Maintenance Activity (OMA) costs. To conduct the analysis, the inflation adjusted OMA costs from Chapter IV, Figure 4-5, were assumed to be dependent upon the intensity of the flight hours. Therefore, the OMA costs were analyzed on the Y-axis with flight hours on the X-axis. The table includes the Marine units, although their costs are affected by their use of the active duty MALS and MAGs and, to a lesser degree, their transition process. The first six months after their transition date were not considered for the analysis. With R^2 values around 49% and 58% respectively, the relationship between MAG-46 and MAG-49A costs in terms of the flight hours flown by these units, are not described by the regression line very well. If only the last two years data is considered for

MAG-42A, MAG-46, and MAG-49A, the regression values that result are much improved:

	MAG-42A	MAG-46	MAG-49A
Constant:	18776.91	-4687.41	-4517.42
Std Error of the Y Est:	58044.98	3828.98	41321.96
R Squared:	.93	.91	.95
X Coefficient:	263.30	14.02	220.87
Std Error of the X Coefficient:	15.61	.92	10.93

These results indicate a more accurate capture of the OMA to flight hour relationship. The perturbations caused by the data from FY 1991 and FY 1992 may have been caused by the inadvertent cost transfers, the transition programs, or other unidentified historical supply and maintenance considerations. Since the cost relationship cannot be accurately determined during the earlier time frame, this data will be excluded from further analysis.

At approximately 75%, the R^2 for VFA-204 suggests a poor relationship or fit between flight hours flown and the resulting costs generated in the OMA cost pool. In performing the initial analysis of the squadrons transitioning to the F/A-18 during the four year period under study, again only the first six months were excluded. This was to allow for the generally poor material condition of the aircraft transferred to the transitioning units. Generally, units transitioning receive their aircraft from other units which frequently balk at transferring their better aircraft, since these aircraft are relied upon for their own performance. In addition, the

OMA COSTS VERSUS FLIGHT HOURS

Unit:	Constant	Std Err of Y Est	R Squared	X Coef	Std Err of Coef
MAG41	26175.11	20140.76	0.978	185.70	7.03
MAG42A	19952.10	51262.62	0.935	265.16	12.32
MAG46	-7965.36	23196.85	0.488	24.68	3.72
MAG49A	54360.06	135570.93	0.580	209.52	35.65
VFA203	5758.79	35050.06	0.965	225.19	6.35
VFA204	52843.77	103187.27	0.746	218.84	22.24
VFA303	24641.71	37926.64	0.935	173.62	6.73
VFA305	-67.19	63024.04	0.917	290.33	12.89
VFC12	133149.16	46377.51	0.953	315.60	24.84
VFC13	61324.59	29483.78	0.938	154.88	15.10

Table 5-2: Regression Output for Flight Hours Verses OMA Costs

transitioning squadron may incur higher costs depending upon the schedule and timing of the receipt of their aircraft. If the unit is restricted to a small number of aircraft for an extended amount of time, the increased utilization rate may dictate more maintenance, more often, because of wear and tear on the aircraft and the cyclic nature of the maintenance actions. Considering these possibilities in the case of VFA-204 and deleting the first year's data results in an R^2 of .81. This result has improved, but it is probably still being influenced by the cumulative nature of the data and the high costs early in the year. By restricting the analysis to the last two years' data, FY 1993 and FY 1994, the following regression output results:

Constant:	17781.84
Std Error of the Y Est:	23560.98
R Squared:	.98
X Coefficient:	213.47
Std Error of the X Coefficient:	6.46

The regression line for the last two years' data describes the relationship between OMA cost and flight hours to the same degree as the other units in the analysis.

Finally, the R^2 values for VFC-12 and VFC-13, .95 and .94, appear to indicate that the relationship between their OMA costs and flight hours is described well by the regression line. However, the low number of observations is a concern, especially when considered with the impact on maintenance costs as a result of transitioning. It may be that both squadrons are still in the high cost phase of unscheduled maintenance before falling to a steady state level. This may also be signaled by the relatively high standard error in the X Coefficient, 24.84, for VFC-12. For this reason these squadrons will not be considered for further analysis.

E. FLIGHT HOURS VERSUS IMA COSTS

To identify the relationship between flight hours and the Intermediate Maintenance Activity (IMA) cost pool, the adjusted IMA cost information found and listed in Chapter IV, Figure 4-6 and the flight hours, Figure 4-3, was used. The results of the regression analysis, again minus the number of degrees of freedom and the number of observations, is shown in Table 5-3.

Given the negative influences: time lag, wide cost variances in repair verses replace, maintenance management's ability to liaison with AIMD and cost shifting to active duty units at some repair facilities, the results of regression analysis are understandably lower. However the wide disparity in VFA-203, VFA-303, and VFA-305 require an additional explanation.

These three reserve units are the only units directly supported by active duty F/A-18 bases: NAS Cecil and NAS Lemoore, and their supply systems. The central focus of these shore installations is the deploying, active duty units. This focus directly affects the IMA and the Aviation Depot Level Repairables, as discussed in the next section of this chapter. The best example and one of the primary cost drivers at these

IMA COSTS VERSUS FLIGHT HOURS

Unit:	Constant	Std Err of Y Est	R Squared	X Coef	Std Err of Coef
MAG41	-152303.65	71027.92	0.906	307.85	24.81
MAG42A	-32675.36	52413.47	0.924	247.60	12.60
MAG46	-86267.49	155758.55	0.840	388.30	25.01
MAG49A	-9821.07	76175.04	0.820	213.45	20.04
VFA203	3611.20	168689.11	0.593	250.03	30.54
VFA204	8373.72	53480.23	0.941	263.79	11.53
VFA303	-13034.27	140089.90	0.644	225.47	25.01
VFA305	-134845.34	220507.26	0.641	409.15	45.11
VFC12	-12961.96	36802.04	0.822	119.84	19.71
VFC13	38214.88	43936.51	0.843	138.09	22.50

Table 5-3: Regression Output for Flight Hours Verses IMA Costs

two levels are the F/A-18 General Electric F-404 engines. Squadrons in final preparation for deployment obtain a higher supply precedence and receive engines and engine components with lower life-cycle hours. That is, these parts have more flight time remaining until they must be turned in for preventive maintenance and reconditioning. Typically, non-deploying units, like the reserves at these bases, receive the high-time "turn-ins" from the deploying units. Although certified by the maintenance depots, these parts frequently require more maintenance, and of course must be removed more often as their hours expire. The prevailing logic supporting this policy is that the reserves will typically fly fewer hours than the active duty in any given period of time and so do not incur a higher rate of engine changes than their active duty counterparts.

Beginning in March 1992, the Aviation Supply Office (ASO) began decreasing the engine life-cycle limitations for the F/A-18 F-404 engines. The sudden increase in cyclic engine maintenance requirements and the deployment cycles of the active duty units has affected both IMA and AVDLR costs for these three units and resulted in the lower regression values. Because NAS Cecil Field, Jacksonville, FL directly supports VFA-203 and NAS Lemoore, CA directly supports VFA-303 and VFA-305 (prior to their decommissioning) with IMA and AVDLR maintenance, the IMA maintenance costs for these three units was affected the most by the changes. The precise effect of the changes can not be quantified for the IMA cost pool, because it is not known exactly which components were influenced and to what degree they were influenced.

These changes affect the analysis of the data for these units because the changes occurred in the middle of the period being analyzed. After the "bow-wave" effect of the changes smooth out, modifying the data for its affect will not be required. Then the only adjustments required will be for

inflation and any identifiable DBOF rate changes. The increased use of the IMA capabilities and costs will be the same across all the units.

F. FLIGHT HOURS VERSUS AVDLR COSTS

Table 5-4 provides the result of the regression analysis program for flight hours and the Aviation Depot Level Repairables cost pool. The data used for the analysis is shown in Figure 4-3 (flight hour costs) and Figure 4-7 (AVDLR costs) in Chapter IV.

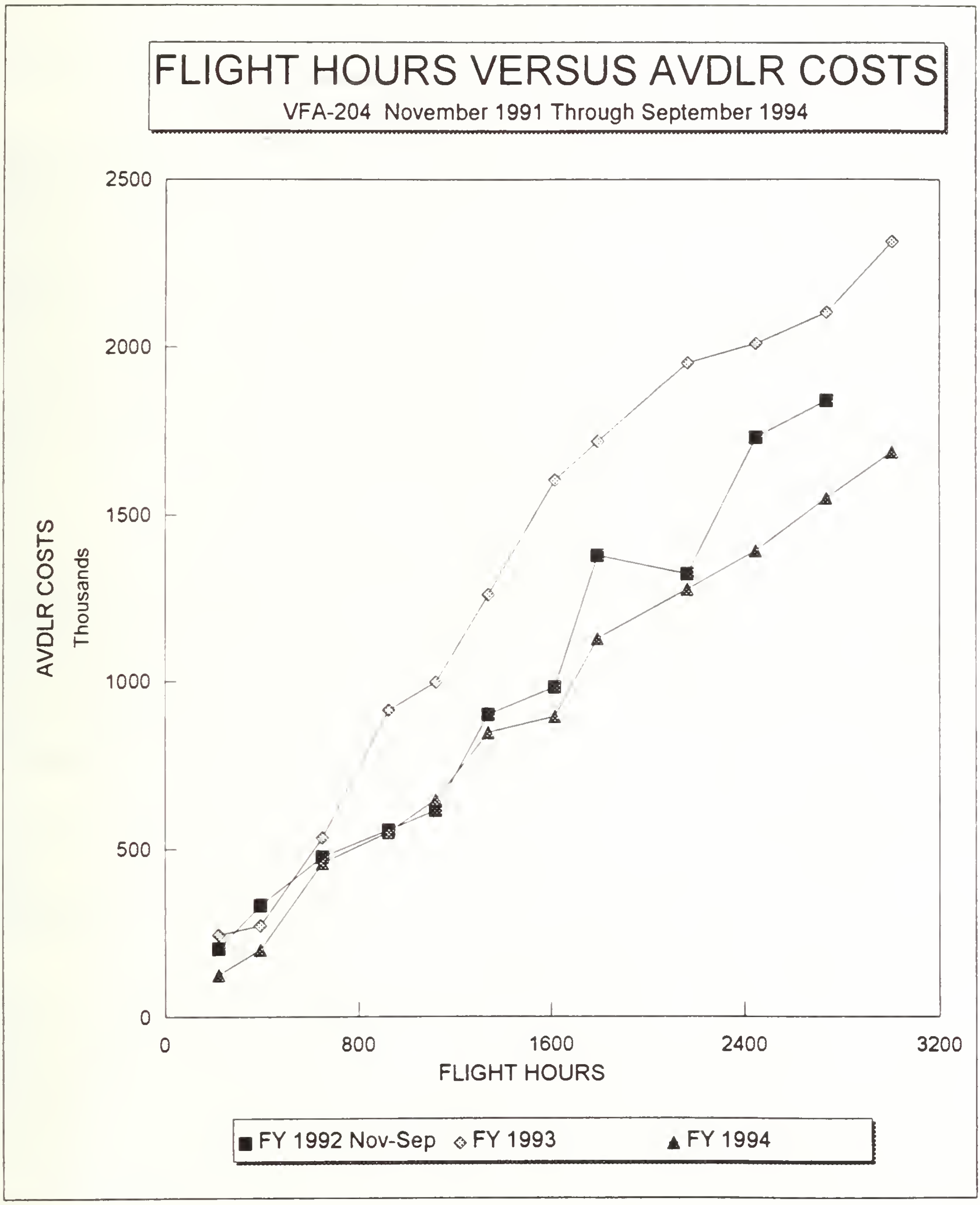
A further inspection of the adjusted data for VFA-204 shows significantly lower costs charged to the AVDLR cost pool in FY 1994. The lower costs for this last year of the analysis and the correspondingly higher mid-year (FY 1993) costs drive the R^2 to its low value. Graph 5-1 shows the annual AVDLR costs versus flight hours for this unit. A number of reasons could account for this variation, each illustrating the difficulty in modeling this cost pool for squadrons in their unique environments. The reasons include:

- A new Maintenance Officer able to use cost saving alternatives to the AVDLR maintenance system.

AVDLR COSTS VERSUS FLIGHT HOURS

Unit:	Constant	Std Err of Y Est	R Squared	X Coef	Std Err of Coef
MAG41	-227682.41	196816.34	0.798	546.79	68.74
MAG42A	-124385.18	194072.20	0.893	763.89	46.63
MAG46	-102553.26	160150.25	0.916	576.56	25.72
MAG49A	-48352.12	151919.95	0.885	555.19	39.95
VFA203	65820.80	336459.45	0.777	771.17	60.92
VFA204	60408.27	358679.59	0.679	646.09	77.32
VFA303	-104500.87	290357.44	0.822	749.81	51.52
VFA305	-209572.44	231887.59	0.904	988.78	47.44
VFC12	85069.65	61898.93	0.897	199.13	23.84
VFC13	-116100.69	61898.93	0.960	409.86	31.70

Table 5-4: Regression Output for Flight Hours Verses AVDLR Costs



Graph 5-1: Annual AVDLR Costs for VFA-204

- Less influence from the engine life-cycle changes as a result of the unit's remote location from active-duty units. VFA-204 is located in New Orleans, LA.

- Improved aircraft condition, resulting in less demand on the AVDLR maintenance and cost systems.

- Mathematically, the failure to fully capture F/A-18 cost increases in FY 1993 because of the blanket data source, NAVCOMPT 7111 DBOF rates.

Of note, an inspection of VFA-204's two other maintenance cost pools, OMA and IMA, indicates a slight decrease in cost for FY 1994, but a high degree of consistency in the other years. This implies the different methods to compute the DBOF rate changes and the effect of the engine life-cycle changes are probably having the most profound effects.

G. SUMMARY

A simple regression output from a Lotus Database program was the tool used to define the relationships between the four cost pools and squadron flight hours. The techniques used in preparing the data for analysis were applied consistently to all four of the cost pools and yielded fairly consistent, definable results.

Because the Reserves fly almost exclusively from contract fuel sites, only rarely purchasing non-contract fuel, the regression analysis supported an extremely close relationship between fuel and flight hours.

The OMA costs for each squadron were also found to be closely defined by the amount of flying accomplished by the squadron. Since OMA costs primarily consist of consumable parts used as a function of flight hours, landings, or other cyclic processes, the results were not totally unexpected.

The final two cost pools showed more variation and are therefore the most difficult to model. This is however consistent with expectations, as OMA and AVDLR consist of more

complex maintenance actions, conducted on a more periodic basis. Finally, these two levels are also affected by widely varying time lags and price variances which compound the difficulty in both managing and modeling costs.

Although there are many factors that affect aircraft operational maintenance and fuel costs, the level of flight operations is a good indicator of cost. The next chapter, Chapter VI, explores the conclusions of this research and presents some topics for further study.

VI. SUMMARY AND RECOMMENDATIONS

A. INTRODUCTION

In an effort to better understand the factors affecting Flight Hour Program costs, this thesis used the mathematical technique of regression analysis to define cost trends within four cost pools of ten Naval Reserve F/A-18 squadrons. The four cost pools--Fuel, Organizational Maintenance Activity (OMA), Intermediate Maintenance Activity (IMA), and Aviation Depot Level Repairables (AVDLR)--are an integral part of the Planning, Programming and Budgeting System (PPBS) used to resource the Navy's and Naval Reserve's Flight Hour Program. The database, provided by Commander Naval Air Reserve Force, New Orleans, LA, consisted of these four cost pools and cumulative flight hour data for Fiscal Years 1991 through 1994. The objective of the database analysis was to support the null hypothesis that the number of flight hours, as an independent variable, could be used to estimate the level of the four cost pools, the dependent variables.

B. RESULTS OF THE ANALYSIS

Flight hours was determined to be only one of many identifiable influences affecting fuel and the three levels of maintenance cost. The research and analysis found that there are different factors affecting the four cost pools; therefore, each cost pool will be addressed separately.

1. Flight Hours and Fuel Costs

The analysis of fuel costs and flight hours supported the assertion that the two are closely related. After modifying the costs for inflationary effects by adjusting them for the yearly fuel contract cost, without exception, the fuel costs varied directly with changes in the flight hours. A tight fit was found in the data.

Typically, the fuel loads are scheduled by the squadron for the mission to be flown. If not, the mission pilot or

Mission Commander for multi-flight taskings will usually inform maintenance of the required fuel load prior to preflighting the aircraft. Since the aircraft performance is highly weight sensitive and extra fuel represents a decline in performance, only the amount of fuel required for mission accomplishment is loaded. The required fuel load is computed using the mission type and duration in flight hours. Since the squadron purchases its fuel as it is loaded aboard the aircraft prior to flight, the close tie between flight hours and fuel cost is not entirely unexpected.

At the end of the fiscal year, each unit attempts to maximize the number of flight hours flown by spending to the limit of its budget for fuel. If there is funding available on 30 September, but no flight hours, then aircraft may be fueled and not flown, carrying the cost over into the new fiscal year. Certain maintenance procedures require grounded engine tests, with no intention for flight and no flight hours logged. Although typically small compared to the total annual budget, these two situations and the differences in engine efficiencies for the various missions represent the sources of variance in the relationship between fuel and flight hours. In this analysis, the engine efficiencies were assumed to be the same across the different squadrons. However, in determining a net relationship for all the units, a variance will exist between the two variables. The same is true when running the engines for squadron ground maintenance operations. This variance, with maintenance costs, was found to have a noticeable impact within approximately six months of transitioning to the aircraft. Therefore, a six month grace period was allowed for the generally poor material condition of aircraft sent to units transitioning to the F/A-18.

The results of an analysis of all the data for each year and all four years reinforce the findings for the individual units. In Table 6-1, the R^2 for the all-year, cumulative data

is significant at 96%. Given the fuel contract cost, the annual cost to fuel F/A-18 flight requirements can be found with a high degree of confidence.

2. Flight Hours and OMA Costs

Within a relevant operating range, the magnitude of the Organizational Maintenance Activity (OMA) cost has been shown to be closely related to flight intensity. Representing the first level of maintenance conducted at the operating or squadron level, the OMA cost pool consists largely of expenditures for consumable items. Typically, the consumables--oil, rags, filters, etc.--are replaced on a cyclic basis defined by the number of landings or the number of flight hours. The cyclic nature and controllability of the cost pool by squadron maintenance managers results in a strengthened correlation between squadron flight hours and the OMA cost pool.

It is expected that the closer the expenditures are to the operational level, the closer the tie will be between cost and an operational metric like flight hours. Even at this level of expenditure, however, the various units exhibit differing efficiencies as defined by their Cost Per Hour (CPH). MAG-46 was able to maintain their reported OMA costs at a consistently, and significantly, lower level than the other nine squadrons. Taking advantage of their location, with nearby ranges and Navy aircraft carriers, and the savings provided by an active-duty Marine Aviation Logistics Support unit at MCAS El Toro, MAG-46's CPH was a factor of ten lower, causing this unit to be dropped from the analysis.

A primary concern for the future is the question of whether or not MAG-46 will be able to continue at these lower cost levels. The pressure is on every unit to identify and save costs. How much longer can the active duty MAGs and MALSs absorb or shift costs for the Reserve units?

FY 1991 - 1994	FUEL	OMA	IMA	AVDLR	OMA without MAG46
Constant	-28921.25	68002.63	-57874.25	-57319.51	43986.67
Std Err of Y Est	146091.16	164884.96	166606.59	340285.72	96167.82
R Squared	0.963	0.372	0.664	0.721	0.743
No of Observations	326	326	326	326	278
Degrees of Freedom	324	324	324	324	276
X Coefficient(s)	939.22	161.00	297.42	693.50	214.83
Std Err of Coef	10.30	11.62	11.74	23.98	7.60
FY 1991					
Constant	-22569.04	55066.60	-86042.48	-47347.85	11063.64
Std Err of Y Est	75197.78	206129.98	210466.02	214394.02	125525.82
R Squared	0.994	0.314	0.604	0.865	0.728
No of Observations	48	48	48	48	36
Degrees of Freedom	46	46	46	46	34
X Coefficient(s)	1087.92	153.92	286.59	599.67	239.25
Std Err of Coef	12.23	33.52	34.23	34.87	25.06
FY 1992					
Constant	10196.55	103154.83	-161133.69	-82554.48	60581.23
Std Err of Y Est	66884.93	192695.29	195678.67	246232.24	116134.50
R Squared	0.990	0.248	0.735	0.842	0.660
No of Observations	73	73	73	73	61
Degrees of Freedom	71	71	71	71	59
X Coefficient(s)	863.63	145.77	430.00	748.05	222.55
Std Err of Coef	10.46	30.14	30.61	38.52	20.81
FY 1993					
Constant	-18351.97	39304.19	-14670.59	-96199.10	18867.60
Std Err of Y Est	39299.75	155705.38	101376.37	329446.95	64085.48
R Squared	0.997	0.475	0.786	0.817	0.891
No of Observations	90	90	90	90	78
Degrees of Freedom	88	88	88	88	76
X Coefficient(s)	858.43	183.74	241.08	861.75	232.07
Std Err of Coef	5.19	20.58	13.40	43.55	9.30
FY 1994					
Constant	-22841.21	71916.05	-33446.13	3723.30	69326.69
Std Err of Y Est	60932.82	132995.77	118541.92	308476.14	85782.76
R Squared	0.993	0.437	0.752	0.637	0.714
No of Observations	115	115	115	115	103
Degrees of Freedom	113	113	113	113	101
X Coefficient(s)	955.65	156.57	275.19	545.08	182.86
Std Err of Coef	7.65	16.70	14.89	38.74	11.52

Table 6-1: Combined Squadron Annual and Multi-year Regression Analysis Results

On a per squadron basis, the resulting R^2 over the years analyzed proved to be very high, averaging approximately .95. When the squadrons are compared with each other on an annual or on a multi-year basis, as shown in Table 6-1, more variance is introduced, although the R^2 remains fairly high. This demonstrates the impact of the management ability of the responsible maintenance personnel. It is a relative statement of their ability to control cost.

Proper maintenance and operator practices can have a big effect on this level of cost. Proper operation extends equipment life and, with proper maintenance practices, further cost efficiencies are realized. Although other factors may affect the result as well. One factor is luck, as no maintenance manager or operator can control an occasional broken windscreen or the like.

Looking at the R^2s that result from the individual years without the influence of MAG-46, FY 1991 was affected by the low number of observations which amplified the squadron efficiency variances. FY 1992 was affected by the transition costs, which were not totally factored out by deleting the first six months after transition from the analysis. FY 1993 was a stable year, with only one transitioning unit, and resulted in a high R^2 at about .9. FY 1994 was less stable, as shown by a .71 R^2, with two transitioning units and two other units decommissioning, both of which impact managers at the squadron level. Given the various unit manager cost management efficiencies, the net OMA costs can be predicted with a fair degree of confidence.

3. Flight Hours and IMA Costs

Intermediate Maintenance Activity level maintenance is subject to the greatest range in usage and costs. A wide variety of aircraft systems are repaired at a wide range of costs. The situation is further complicated by the different bases providing a variety of repair capabilities. When

consideration is given to the differing management abilities at the squadron and IMA level, this level of maintenance cost appears to be totally uncontrolled and unpredictable. The R^2 seems to bear this out with consistently lower results. The R^2 for the multi-year regression is .66, and the highest R^2 was for FY 1993 at .79. Further analysis of the data, however, yields an explanation for the lower trend, as compared to the Fuel and OMA results.

One of the squadrons was picked at random and the data inspected for potential cost lags. As has already been discussed in Chapter IV, costs and repairs can lag up to as much as six months, driving the costs back. These costs can be shifted into another fiscal year; although, in an effort to control and manage their costs, most managers attempt to minimize this occurrence. Of course, this, in and of itself, is an effect on the IMA costs. To conduct the check for time lags, the data for VFA-303 was mathematically distilled into a non-cumulative, monthly form. The monthly costs were shifted back one month and regressed with the monthly flight hours. Because of the autocorrelation[1] effects inherent in a time series analysis, the results would be expected to change. Therefore, the results of two new regression analysis operations were used for the comparison. The monthly, non-cumulative figures were regressed without a lag and the results compared to a regression of the non-cumulative data with just a one month lag. The result of the analysis implied that there was a significant effect caused by time lag: the R^2 improved approximately 20%. Because of the variability in

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[1]Autocorrelation is the effect in successive observations caused by errors that are carried forward through the data. That is, a follow-on observation is biased by an error in the earlier data upon which it is dependent. Therefore, it gives less information about the trend in the relationship it is representing, and the reliability of the analysis decreases. [Ref. 28: p. 212]

this aspect of costing, however, the exact effect of the cost lag is very difficult to specify in a model.

Considering the variable nature and wide range of maintenance charges and the potential effects caused by significant one to six month lags in the IMA costs, the results of the regression analysis of this level are fairly predictive. With low standard deviations of the coefficients, the multi-year model represents a fair degree of correlation in the relationship between flight hours and IMA costs, which can be predicted with some confidence.

4. Flight Hours and AVDLR Costs

Over the time period of the analysis, the Aviation Depot Level Repairable cost pool related to the F/A-18 has endured dramatic changes caused by variations in the "customer" usage rate. Although the rate structure used for costing the maintenance performance at the depot level has remained consistent and easily quantifiable, dramatic changes in the F/A-18 General Electric F-404 engine component life-cycles have complicated the analysis process.

Making up a significant portion of the aircraft AVDLR maintenance cost, the F/A-18 engines are a critical cost component. The specific effects of the engine life-cycle changes on the depot level usage rate were difficult to quantify due to a general lack of specific data. The extent of the engine life-cycle reduction cost effects were still unknown, primarily because the life-cycle changes were an ongoing process. Finally, data for changes in FY 1994 was difficult to obtain as the impact of these changes has not been fully identified, and the life-cycles continue to change.

With the data that was available, fairly reasonable approximations of the effect on cost could be predicted for the changes in the F-404 engine life-cycle. Again however, time lags exist in AVDLR costs and these are difficult to quantify. Management abilities and attempts at cost control

are much more difficult at this level for operational squadron maintenance managers. They are usually too far removed from the depot level maintenance/pricing decision making.

Also like the IMA level, the regression analysis of all the squadrons in a given year indicates the stability of the database in FY 1993 yielded the best results. The variances caused by decommissioning and transitions have a significant impact. Given the instability of the costing environment, the result of the multi-year regression analysis indicates a fairly consistent relationship between flight hours and AVDLR costs. With time and fewer changes in engine component life-cycles, and as indicated by the low standard deviation in the coefficients, reasonable confidence can be assumed in predicting AVDLR costs based on a relationship to flight hours.

C. RECOMMENDATIONS FOR FURTHER STUDY

While researching the Flight Hour Program and analyzing the four maintenance cost pools, a number of areas needing further study were revealed. Concentrated effort in these areas might lead to a deeper insight in the relationships between budgeting, budget execution, maintenance and operations for both active and reserve units.

Dwindling fiscal resources demand that operational and budget managers at every level adapt proven cost efficient methods to maximize the remaining funding. Further investigation into MAG-46's consistently lower Organizational Maintenance Activity costs may yield techniques or processes of cost management applicable to other active duty and reserve F/A-18 units. There is a need to define this unit's relationships with its support units and identify the precise causes of their cost savings and their applicability to other sites.

Research for this thesis indicated a trend in the Air Force moving toward two level maintenance. The Air Force also uses a maintenance squadron concept, removing the aircraft from the flying units and giving responsibility for aircraft maintenance to an entirely different unit devoted to maintenance. In an era of increasing complexity and "black box" repair, one or both of these ideas could result in significant cost savings. Some of the basic repair capability (computer card replacement for instance) could be consolidated at the operational level and the more technically complex repairs shifted to the depot level. When combined with the maintenance squadron concept, the cost savings gained from the economies of scale and fewer levels of maintenance may be significant.

As a result of the cancellation of a number of replacement aircraft programs, fleet aircraft are growing older. As in the case of the P-3C "Orion," Navy aircraft are being operationally flown well beyond their originally intended service life. The replacement aircraft procurement programs for the P-3C and the A-6 "Intruder" have been canceled and follow-on aircraft will not be operational until sometime in the far future. The increasing age of these aircraft have costs in terms of increased maintenance and repair. Parts are more difficult to find and must be replaced more often. Research is needed to quantify the increase in maintenance and repair costs related to aircraft age at every level of maintenance.

Finally, the potential effects of the IMA and AVDLR cost lags was not fully investigated. An indepth analysis of the IMA and AVDLR maintenance and pricing systems and their effect on the squadron budget should be pursued. The use of non-cumulative quarterly data may provide a better model for identifying a relationship to flight hours.

D. CONCLUSION

The methods used for defining and committing the resource requirements needed to ensure the continued freedom of the people of the United States are long and involved. Six year POMs result in two year defense budgets that are debated and negotiated for a year before being ratified and signed into law. The critical nature of its purpose ensures that the defense budget will be planned, programmed and executed in the most efficient manner possible. Ultimately, the defense budget is the tool that guarantees the freedom of the United States while safeguarding, to the maximum extent possible, the lives of the soldiers, sailors, and Marines tasked with policy implementation on the front lines.

This parametric analysis of the variances and costs associated with a significant portion of the Navy's budget, the Flight Hour Program, was intended to add insight and understanding of the various costing nuances and budget interactions that impact Reserve tactical aviation. Predicting the future is difficult. However, incremental increasing, or decreasing, budget requests based on a "gut feel" of the future is no longer an acceptable planning method. With parametric models and analysis, given a level of operational intensity, the required level of resources to operate and succeed can be confidently obtained.

APPENDIX A: REVISED BUDGET ACTIVITY STRUCTURE

OPERATION AND MAINTENANCE, NAVY

BUDGET ACTIVITY 1: OPERATING FORCES

O AIR OPERATIONS

• MISSION AND OTHER FLIGHT OPERATIONS	1A1A
• FLEET AIR TRAINING	1A2A
• INTERMEDIATE MAINTENANCE	1A3A
• AIR OPERATIONS AND SAFETY SUPPORT	1A4A
• AIRCRAFT DEPOT MAINTENANCE	1A5A
• AIRCRAFT DEPOT OPERATIONS SUPPORT	1A6A
• BASE SUPPORT	1A7A

O SHIP OPERATIONS

• MISSION AND OTHER SHIP OPERATIONS	1B1B
• SHIP OPERATIONAL SUPPORT AND TRAINING	1B2B
• INTERMEDIATE MAINTENANCE	1B3B
• SHIP DEPOT MAINTENANCE	1B4B
• SHIP DEPOT OPERATIONS SUPPORT	1B5B
• BASE SUPPORT	1B6B

O COMBAT OPERATIONS/SUPPORT

• COMBAT COMMUNICATIONS	1C1C
• ELECTRONIC WARFARE	1C2C
• SPACE SYSTEMS AND SURVEILLANCE	1C3C
• WARFARE TACTICS	1C4C
• OPERATIONAL METEOROLOGY AND OCEANOGRAPHY	1C5C
• COMBAT SUPPORT FORCES	1C6C
• EQUIPMENT MAINTENANCE	1C7C
• DEPOT OPERATIONS SUPPORT	1C8C
• BASE SUPPORT	1C9C

O WEAPONS SUPPORT

• CRUISE MISSILE	1D1D
• FLEET BALLISTIC MISSILE	1D2D
• IN-SERVICE WEAPONS SYSTEMS SUPPORT	1D3D
• WEAPONS MAINTENANCE	1D4D
• BASE SUPPORT	1D5D

BUDGET ACTIVITY 2: MOBILIZATION

- O READY RESERVE AND PREPOSITIONING FORCES
  - ● SHIP PREPOSITIONING AND SURGE — 2A1F
- O ACTIVATIONS/INACTIVATIONS
  - ● AIRCRAFT ACTIVATIONS/INACTIVATIONS — 2B1G
  - ● SHIP ACTIVATIONS/INACTIVATIONS — 2B2G
- O MOBILIZATION PREPAREDNESS
  - ● FLEET HOSPITAL PROGRAM — 2C1H
  - ● INDUSTRIAL READINESS — 2C2H
  - ● COAST GUARD SUPPORT — 2C3H

BUDGET ACTIVITY 3: TRAINING AND RECRUITMENT

- O ACCESSION TRAINING
  - ● OFFICER ACQUISITION — 3A1J
  - ● RECRUIT TRAINING — 312J
  - ● RESERVE OFFICERS TRAINING CORPS — 3A3J
  - ● BASE SUPPORT — 3A4J
- O BASIC SKILLS AND ADVANCED TRAINING
  - ● SPECIALIZED SKILLS TRAINING — 3B1K
  - ● FLIGHT TRAINING — 3B2K
  - ● PROFESSIONAL DEVELOPMENT EDUCATION — 3B3K
  - ● TRAINING SUPPORT — 3B4K
  - ● BASE SUPPORT — 3B5K
- O RECRUITING AND OTHER TRAINING AND EDUCATION
  - ● RECRUITING AND ADVERTISING — 3C1L
  - ● EXAMINING — 3C2L
  - ● OFF-DUTY AND VOLUNTARY EDUCATION — 3C3L
  - ● CIVILIAN EDUCATION AND TRAINING — 3C4L
  - ● JUNIOR ROTC — 3C5L
  - ● BASE SUPPORT — 3C6L

BUDGET ACTIVITY 4: ADMINISTRATION AND SERVICEWIDE ACTIVITIES

O SERVICEWIDE SUPPORT

● ADMINISTRATION	4A1M
● EXTERNAL RELATIONS	4A2M
● CIVILIAN MANPOWER AND PERSONNEL MANAGEMENT	4A3M
● MILITARY MANPOWER AND PERSONNEL MANAGEMENT	4A4M
● OTHER PERSONNEL SUPPORT	4A5M
● SERVICEWIDE COMMUNICATIONS	4A6M
● BASE SUPPORT	4A7M

O LOGISTICS OPERATIONS AND TECHNICAL SUPPORT

● SERVICEWIDE TRANSPORTATION	4B1N
● PLANNING, ENGINEERING AND DESIGN	4B2N
● ACQUISITION AND PROGRAM MANAGEMENT	4B3N
● AIR SYSTEMS SUPPORT	4B4N
● HULL, MECHANICAL AND ELECTRICAL SUPPORT	4B5N
● COMBAT/WEAPONS SYSTEMS	4B6N
● SPACE AND ELECTRONIC WARFARE SYSTEMS	4B7N
● BASE SUPPORT	4B8N

O INVESTIGATIONS AND SECURITY PROGRAMS (NOT SEPARATELY IDENTIFIED OUTSIDE DON)

● NAVAL INVESTIGATIVE SERVICE	4C1P
● CONSOLIDATED CRYPTOLOGIC PROGRAMS	4C2P
● GENERAL DEFENSE INTELLIGENCE PROGRAM	4C3P
● FOREIGN COUNTERINTELLIGENCE	4C4P
● BASE SUPPORT	4C5P

O SUPPORT OF OTHER NATIONS

● INTERNATIONAL HEADQUARTERS AND AGENCIES	4D1Q

O MEDICAL ACTIVITIES (FOR REIMBURSABLE E/S FROM OSD(HA))

● MEDICAL ACTIVITIES	4E1R

OPERATION AND MAINTENANCE, NAVY RESERVE

BUDGET ACTIVITY 1: OPERATING FORCES

O AIR OPERATIONS

● MISSION AND OTHER FLIGHT OPERATIONS	1A1A
● AVIATION TRAINING	1A2A
● INTERMEDIATE MAINTENANCE	1A3A
● AIR OPERATIONS AND SAFETY SUPPORT	1A4A
● AIRCRAFT DEPOT MAINTENANCE	1A5A
● AIRCRAFT DEPOT OPERATIONS SUPPORT	1A6A
● BASE SUPPORT	1A7A

O SHIP OPERATIONS

● MISSION AND OTHER SHIP OPERATIONS	1B1B
● INTERMEDIATE MAINTENANCE	1B3B
● SHIP DEPOT MAINTENANCE	1B4B
● BASE SUPPORT	1B6B

O COMBAT OPERATIONS/SUPPORT

● COMBAT COMMUNICATIONS	1C1C
● COMBAT SUPPORT FORCES	1C6C
● BASE SUPPORT	1C9C

O WEAPONS SUPPORT

● WEAPONS MAINTENANCE	1D4D

BUDGET ACTIVITY 4: ADMINISTRATION AND SERVICEWIDE ACTIVITIES

O SERVICEWIDE SUPPORT

● ADMINISTRATION	4A1M
● EXTERNAL RELATIONS	4A2M
● MILITARY MANPOWER AND PERSONNEL MANAGEMENT	4A4M
● OTHER PERSONNEL SUPPORT	4A6M
● BASE SUPPORT	4A7M
● WEAPON SYSTEM SUPPORT	4A8M

OPERATION AND MAINTENANCE, MARINE CORPS

BUDGET ACTIVITY 1: OPERATING FORCES

- O EXPEDITIONARY FORCES

● OPERATIONAL FORCES	1A1A
● FIELD LOGISTICS	1A2A
● DEPOT MAINTENANCE	1A3A
● BASE SUPPORT	1A4A

- O USMC PREPOSITIONING

● MARITIME PREPOSITIONING FORCE	1B1B
● NORWAY PREPOSITIONING	1B2B

BUDGET ACTIVITY 3: TRAINING AND RECRUITMENT

- O ACCESSION TRAINING

● OFFICER ACQUISITION	3A1C
● RECRUIT TRAINING	3A2C
● BASE SUPPORT	3A3C

- O BASIC SKILLS AND ADVANCED TRAINING

● SPECIALIZED SKILLS TRAINING	3B1D
● FLIGHT TRAINING	3B2D
● PROFESSIONAL DEVELOPMENT EDUCATION	3B3D
● TRAINING SUPPORT	3B4D
● BASE SUPPORT	3B5D

- O RECRUITING AND OTHER TRAINING AND EDUCATION

● RECRUITING AND ADVERTISING	3C1F
● EXAMINING	3C2F
● OFF-DUTY AND VOLUNTARY EDUCATION	3C3F
● CIVILIAN EDUCATION AND TRAINING	3C4F
● JUNIOR ROTC	3C5F
● BASE SUPPORT	3C6F

BUDGET ACTIVITY 4: ADMINISTRATION AND SERVICEWIDE ACTIVITIES

- O SERVICEWIDE SUPPORT

● ADMINISTRATION	4A1G
● LOGISTICS SUPPORT	4A2G
● SPECIAL SUPPORT	4A3G
● SERVICEWIDE TRANSPORTATION	4A4G
● BASE SUPPORT	4A5G

APPENDIX B: MEMO FLIGHT HOUR COST REPORT

From: Unit sending report
To: COMNAVAIRESFOR

Info: Interested commands/units being reporting upon
UNCLAS//N07310//

SUBJ: MEMO RECORD FLIGHT HOUR COST REPORT (RPT SYM 7310-7)
REF A: COMNAVRESFOR P7100 (BUDGET AND FINANCIAL GUIDANCE MANUAL)

1. PER REF A, THE FOLLOWING IS SUBMITTED:

A. UNIT(S)	List of the units contained in the report
B. TMS/TEC	Type/Model/Series and four digit Technical Equipment Code
C. YR/MO	Year and Month of the reported data
D.1. TRAINING	Flight hours dedicated to training
2. OPERATIONS	Flight hours dedicated to operational tasking
3. SERVICE SUP	Flight hours used in interservice support operations
4. DRUG OPS	Flight hours flown in support of drug interdiction operations
5. TOTAL HRS	Total of D.1. through D.4.
E. FUEL COSTS	Total spent for fuel
F. OMA COSTS	Total spent for Organizational Maintenance support
G. IMA COSTS	Total spent for Intermediate Maintenance support
H. DLR COSTS	Total spent for Depot Level Repairables
I. CONS	Consumption of fuel in barrels (42 gal/bbl)
J. JP4	Cost of type of fuel used by Air Force Bases
K. JP5	Cost of type of fuel used at Naval Air Stations
L. JP8	Cost of type of fuel used at Naval Air Stations
M. INTROPLANE	Fuel obtained not covered under Navy contracts
N. INTRO COST	Cost of non-contract fuel
O. REIMB HRS	Flight hours flown in support of other agencies for which reimbursement of costs will be received
P. REIMB COST	Total cost of above flight hours
Q. CPH YTD	Cost per hour (cumulative) year-to-date
R. CPH MO	Cost per hour for monthly costs and hours

APPENDIX C: SQUADRON FLIGHT HOURS, FUEL AND MAINTENANCE COSTS

Unit: **MAG41**

MONTH		FLT HRS	FUEL	OMA	IMA	AVDLR
October	FY 1991	0	0	0	0	0
November		0	0	0	0	0
December		0	0	0	0	0
January		0	0	0	0	0
February		0	0	0	0	0
March		0	0	0	0	0
April		0	0	0	0	0
May		0	0	0	0	0
June		0	0	0	0	0
July		0	0	0	0	0
August		0	0	0	0	0
September		0	0	0	0	0
October	FY 1992	0	0	0	0	0
November		0	0	0	0	0
December		0	0	0	0	0
January		0	0	0	0	0
February		0	0	0	0	0
March		0	0	0	0	0
April		0	0	0	0	0
May		0	0	0	0	0
June		0	0	0	0	0
July		0	0	0	0	0
August		0	0	0	0	0
September		0	0	0	0	0
October	FY 1993	15	695	1734	464	258
November		46	654	1078	219	1285
December		121	620	609	160	804
January		193	686	514	179	1082
February		443	693	326	140	713
March		742	741	236	142	907
April		981	729	212	140	720
May		1245	759	191	246	693
June		1455	779	218	234	730
July		1721	804	203	218	710
August		1956	805	191	245	740
September		2110	800	229	265	725
October	FY 1994	269	745	311	256	752
November		497	803	249	198	488
December		750	798	249	163	413
January		1025	800	237	155	400
February		1255	862	234	144	430
March		1500	910	237	146	512
April		1686	929	219	272	939
May		1864	923	216	271	869
June		2106	933	200	282	988
July		2336	946	206	331	1212
August		2593	933	219	366	1430
September		2724	947	208	367	1463

Unit:MAG46/42A

MONTH		FLT HRS	FUEL	OMA	IMA	AVDLR
October	FY 1991	0	0	0	0	0
November		0	0	0	0	0
December		0	0	0	0	0
January		0	0	0	0	0
February		0	0	0	0	0
March		0	0	0	0	0
April		0	0	0	0	0
May		0	0	0	0	0
June		22	797	4221	5854	9022
July		59	1125	1880	1820	2807
August		99	1197	1437	737	1838
September		215	1202	833	163	924
October	FY 1992	114	876	499	223	881
November		270	841	423	328	744
December		449	817	361	199	672
January		694	799	302	267	670
February		958	731	259	242	607
March		1151	814	256	185	610
April		1287	822	340	202	711
May		1500	781	306	195	677
June		1745	780	285	211	767
July		1901	819	304	242	800
August		2163	812	281	252	825
September		2330	809	284	331	915
October	FY 1993	180	787	633	269	939
November		481	753	256	199	523
December		686	765	319	194	992
January		874	744	361	225	1020
February		1041	762	352	235	1030
March		1336	781	322	236	1045
April		1571	794	343	257	1170
May		1730	803	362	283	1231
June		2076	801	314	257	1197
July		2282	775	313	237	1088
August		2466	785	298	236	1035
September		2646	793	298	236	1132
October	FY 1994	215	853	197	230	1156
November		470	802	234	293	1279
December		634	959	250	187	1311
January		828	958	324	227	1311
February		1032	959	287	258	1596
March		1318	941	251	321	1644
April		1489	934	259	308	1640
May		1646	926	258	318	1631
June		1861	924	264	329	1686
July		2175	925	259	322	1616
August		2393	914	246	298	1605
September		2550	930	270	322	1631

Unit:MAG46

MONTH		FLT HRS	FUEL	OMA	IMA	AVDLR
October	FY 1991	245	823	4	54	275
November		487	1192	9	370	416
December		704	1145	9	559	615
January		963	1058	57	418	527
February		1325	1046	44	450	543
March		1577	1074	40	417	468
April		1856	1089	50	371	452
May		2179	1091	46	403	580
June		2473	1085	42	393	564
July		2493	1120	38	373	463
August		3134	1107	34	354	515
September		3398	1134	33	364	522
October	FY 1992	344	721	3	208	329
November		651	762	19	190	285
December		828	756	16	246	354
January		1056	755	18	282	379
February		1320	745	15	283	573
March		1572	737	17	320	557
April		1886	719	16	346	570
May		2318	657	14	320	534
June		2339	712	16	379	604
July		2540	725	26	547	643
August		2775	738	17	528	641
September		2991	745	16	508	630
October	FY 1993	296	845	6	96	546
November		506	869	7	393	743
December		726	859	6	346	752
January		940	859	6	508	788
February		1165	851	7	437	918
March		1482	845	6	396	930
April		1727	847	10	423	1023
May		2067	820	9	373	892
June		2356	815	10	365	802
July		2571	817	12	362	835
August		2855	818	15	363	826
September		2930	822	16	379	857
October	FY 1994	194	950	3	172	1535
November		447	930	11	171	928
December		621	939	13	190	957
January		862	965	11	196	929
February		1067	967	10	233	802
March		1286	975	13	278	785
April		1453	1008	13	262	872
May		1749	964	12	330	1047
June		2041	971	13	274	1155
July		2236	988	13	308	1231
August		2593	965	13	340	1360
September		2750	962	14	336	1443

Unit:MAG41A/49A

MONTH		FLT HRS	FUEL	OMA	IMA	AVDLR
October	FY 1991	0	0	0	0	0
November		0	0	0	0	0
December		0	0	0	0	0
January		0	0	0	0	0
February		0	0	0	0	0
March		0	0	0	0	0
April		0	0	0	0	0
May		0	0	0	0	0
June		0	0	0	0	0
July		0	0	0	0	0
August		0	0	0	0	0
September		0	0	0	0	0
October	FY 1992	0	0	0	0	0
November		0	0	0	0	0
December		0	0	0	0	0
January		21	724	3984	1314	1776
February		73	646	1772	884	1904
March		178	660	1326	551	929
April		353	647	979	311	588
May		713	658	577	215	385
June		879	668	621	196	556
July		1026	695	689	195	512
August		1316	690	555	154	486
September		1513	707	409	148	501
October	FY 1993	209	751	280	113	253
November		437	793	223	100	310
December		557	776	219	101	319
January		818	768	190	121	505
February		1027	764	177	132	616
March		1285	765	194	116	667
April		1499	786	209	240	733
May		1676	790	234	260	850
June		1969	790	220	231	838
July		2128	762	273	233	878
August		2454	809	254	208	806
September		2730	793	245	216	826
October	FY 1994	205	900	271	140	282
November		470	842	233	463	1913
December		675	900	207	477	1917
January		798	885	236	417	1853
February		1013	873	235	358	2004
March		1283	900	281	378	1610
April		1478	920	276	311	1425
May		1599	921	263	312	1618
June		2021	878	214	255	1845
July		2226	887	206	283	1201
August		2419	902	218	306	1241
September		2600	922	211	321	1207

Unit:VFA-203

MONTH		FLT HRS	FUEL	OMA	IMA	AVDLR
October	FY 1991	139	1133	273	107	712
November		349	1109	247	107	688
December		548	1102	265	98	584
January		805	1117	266	84	505
February		1099	1117	262	94	493
March		1370	1112	267	111	569
April		1641	1112	247	95	530
May		1911	1108	259	94	495
June		2090	1100	263	122	535
July		2384	1100	256	122	532
August		2770	1099	248	124	526
September		2967	1107	245	212	555
October	FY 1992	229	710	243	137	484
November		440	728	176	110	486
December		595	739	198	248	1131
January		794	761	231	238	1004
February		1083	782	208	254	964
March		1314	770	207	253	858
April		1534	767	226	258	977
May		1936	767	194	216	845
June		2084	764	207	242	856
July		2201	763	215	252	907
August		2365	763	222	307	862
September		2572	751	216	322	904
October	FY 1993	151	746	475	426	1589
November		379	759	295	347	1228
December		564	770	272	280	772
January		765	777	291	360	1675
February		1048	796	250	320	1521
March		1287	794	252	322	1517
April		1519	789	255	326	1544
May		1724	795	264	327	1551
June		2082	806	230	316	1510
July		2288	806	235	288	1373
August		2450	804	240	270	1311
September		2613	806	243	274	1260
October	FY 1994	191	973	350	288	1636
November		452	900	234	239	1808
December		591	1007	215	303	1964
January		711	988	258	399	2715
February		1003	926	230	498	3160
March		1222	931	218	535	2893
April		1444	931	216	494	2505
May		1593	933	221	513	2726
June		1634	935	249	618	3285
July		1936	948	222	526	2794
August		2142	940	228	535	2755
September		2403	935	229	526	2616

Unit:VFA-204

MONTH		FLT HRS	FUEL	OMA	IMA	AVDLR
October	FY 1991	0	0	0	0	0
November		0	0	0	0	0
December		0	0	0	0	0
January		0	0	0	0	0
February		0	0	0	0	0
March		0	0	0	0	0
April		0	0	0	0	0
May		73	1121	1831	1151	566
June		115	1092	1538	985	766
July		233	1055	878	524	989
August		356	1058	641	384	838
September		477	1101	525	352	679
October	FY 1992	171	809	354	45	685
November		358	780	273	43	630
December		549	763	303	227	672
January		666	768	357	291	793
February		866	736	310	248	711
March		1057	753	417	223	646
April		1162	731	564	280	859
May		1495	748	371	227	728
June		1796	752	341	260	849
July		1910	758	340	265	766
August		2170	769	315	302	882
September		2310	764	338	302	881
October	FY 1993	137	605	453	792	2460
November		455	692	199	300	824
December		669	689	208	362	1099
January		906	709	230	473	1387
February		1081	731	240	438	1270
March		1262	741	253	384	1372
April		1576	793	273	359	1399
May		1817	794	252	334	1300
June		2008	800	254	315	1336
July		2207	801	241	320	1251
August		2501	784	235	335	1155
September		2650	798	235	348	1200
October	FY 1994	221	913	327	418	1267
November		392	941	300	309	1129
December		650	927	248	354	1561
January		925	975	212	290	1312
February		1120	960	246	267	1278
March		1337	957	225	362	1400
April		1614	972	206	325	1224
May		1791	981	224	311	1391
June		2162	976	217	346	1303
July		2444	968	198	320	1255
August		2736	958	215	309	1248
September		3005	950	221	306	1239

Unit:VFA-303

MONTH		FLT HRS	FUEL	OMA	IMA	AVDLR
October	FY 1991	296	980	105	162	202
November		561	1002	148	89	378
December		779	978	157	99	431
January		1043	977	188	81	446
February		1340	1013	143	104	430
March		1605	1011	161	103	433
April		1776	1038	167	134	511
May		1987	1033	168	142	519
June		2226	1020	171	150	556
July		2483	1027	182	141	540
August		2834	1023	165	136	588
September		3040	1022	176	209	604
October	FY 1992	223	740	286	131	836
November		408	720	237	98	650
December		631	713	218	167	600
January		864	727	262	168	508
February		1042	731	222	215	577
March		1370	727	204	215	437
April		1568	719	207	286	558
May		1729	717	201	272	683
June		1939	723	195	262	700
July		2158	721	206	286	758
August		2490	728	195	281	737
September		2665	727	189	369	758
October	FY 1993	216	738	460	50	273
November		428	828	265	181	766
December		661	783	232	54	832
January		839	796	275	190	914
February		1157	805	238	140	1039
March		1435	793	225	151	1023
April		1701	805	222	196	1092
May		2003	798	228	169	1008
June		2261	769	235	215	1090
July		2591	782	218	211	1200
August		2760	781	216	242	1439
September		2933	784	199	230	1381
October	FY 1994	182	867	422	321	2429
November		487	906	293	596	3371
December		629	898	269	597	3572
January		862	885	222	512	2991
February		1097	888	191	418	2477
March		1358	880	177	387	2295
April		1537	840	178	430	2319
May		1799	860	167	411	2408
June		2095	861	171	399	1775
July		2122	852	170	418	1923
August		2122	860	183	454	2043
September		2122	863	184	454	2078

Unit:VFA-305

MONTH		FLT HRS	FUEL	OMA	IMA	AVDLR
October	FY 1991	266	1119	14	30	156
November		453	1075	367	130	603
December		741	912	217	60	274
January		931	1108	301	88	554
February		1178	1085	305	128	699
March		1335	1136	310	225	576
April		1399	1055	356	252	834
May		1592	1073	377	264	836
June		1904	1101	345	363	836
July		2095	1079	358	320	751
August		2359	1072	346	321	804
September		2645	1052	332	338	854
October	FY 1992	254	866	126	140	1010
November		469	744	328	489	1295
December		686	725	322	533	1115
January		961	701	236	467	1024
February		1214	695	349	517	823
March		1450	694	253	462	849
April		1616	699	252	562	851
May		1811	689	245	574	1130
June		1979	705	259	573	1008
July		2200	716	265	575	1086
August		2477	711	249	566	999
September		2723	718	243	579	1005
October	FY 1993	249	857	367	27	113
November		441	775	330	199	772
December		579	763	281	395	1186
January		838	763	279	178	1184
February		991	778	284	185	1053
March		1260	780	289	218	1347
April		1448	757	315	280	1532
May		1603	762	329	265	1521
June		1825	728	312	235	1491
July		2178	775	278	229	1540
August		2392	770	299	221	1513
September		2589	770	293	222	1395
October	FY 1994	240	583	403	172	1286
November		408	916	386	314	2073
December		692	883	268	181	1690
January		863	871	295	194	1735
February		976	857	328	237	1778
March		1175	852	319	226	1813
April		1332	863	333	299	1874
May		1590	868	318	308	1908
June		1805	872	310	301	2013
July		1835	884	325	321	2050
August		1844	866	330	355	2144
September		1844	866	330	389	2155

Unit:VFC-12

MONTH		FLT HRS	FUEL	OMA	IMA	AVDLR
October	FY 1991	0	0	0	0	0
November		0	0	0	0	0
December		0	0	0	0	0
January		0	0	0	0	0
February		0	0	0	0	0
March		0	0	0	0	0
April		0	0	0	0	0
May		0	0	0	0	0
June		0	0	0	0	0
July		0	0	0	0	0
August		0	0	0	0	0
September		0	0	0	0	0
October	FY 1992	0	0	0	0	0
November		0	0	0	0	0
December		0	0	0	0	0
January		0	0	0	0	0
February		0	0	0	0	0
March		0	0	0	0	0
April		0	0	0	0	0
May		0	0	0	0	0
June		0	0	0	0	0
July		0	0	0	0	0
August		0	0	0	0	0
September		0	0	0	0	0
October	FY 1993	0	0	0	0	0
November		0	0	0	0	0
December		0	0	0	0	0
January		0	0	0	0	0
February		0	0	0	0	0
March		0	0	0	0	0
April		0	0	0	0	0
May		0	0	0	0	0
June		19	825	4056	753	1333
July		38	825	2013	753	666
August		87	841	891	692	1101
September		236	737	665	134	720
October	FY 1994	55	715	477	286	786
November		101	832	912	237	819
December		157	864	1091	206	1300
January		237	930	912	184	1209
February		283	950	1057	164	1278
March		478	948	631	104	1212
April		689	951	581	103	1083
May		893	952	483	118	947
June		1071	943	467	86	978
July		1377	930	405	127	825
August		1668	937	387	111	720
September		1925	926	460	194	599

Unit:VFC-13

MONTH		FLT HRS	FUEL	OMA	IMA	AVDLR
October	FY 1991	0	0	0	0	0
November		0	0	0	0	0
December		0	0	0	0	0
January		0	0	0	0	0
February		0	0	0	0	0
March		0	0	0	0	0
April		0	0	0	0	0
May		0	0	0	0	0
June		0	0	0	0	0
July		0	0	0	0	0
August		0	0	0	0	0
September		0	0	0	0	0
October	FY 1992	0	0	0	0	0
November		0	0	0	0	0
December		0	0	0	0	0
January		0	0	0	0	0
February		0	0	0	0	0
March		0	0	0	0	0
April		0	0	0	0	0
May		0	0	0	0	0
June		0	0	0	0	0
July		0	0	0	0	0
August		0	0	0	0	0
September		0	0	0	0	0
October	FY 1993	0	0	0	0	0
November		0	0	0	0	0
December		0	0	0	0	0
January		0	0	0	0	0
February		0	0	0	0	0
March		0	0	0	0	0
April		0	0	0	0	0
May		0	0	0	0	0
June		0	0	0	0	0
July		28	869	0	559	857
August		81	873	0	562	861
September		171	898	547	567	609
October	FY 1994	41	916	934	35	2114
November		123	919	323	166	720
December		268	877	265	221	704
January		476	916	227	153	647
February		671	913	227	181	853
March		920	915	250	308	698
April		1120	942	269	303	864
May		1349	924	234	185	951
June		1640	917	222	204	959
July		1961	936	196	206	959
August		2222	923	181	194	934
September		2435	933	191	185	1197

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